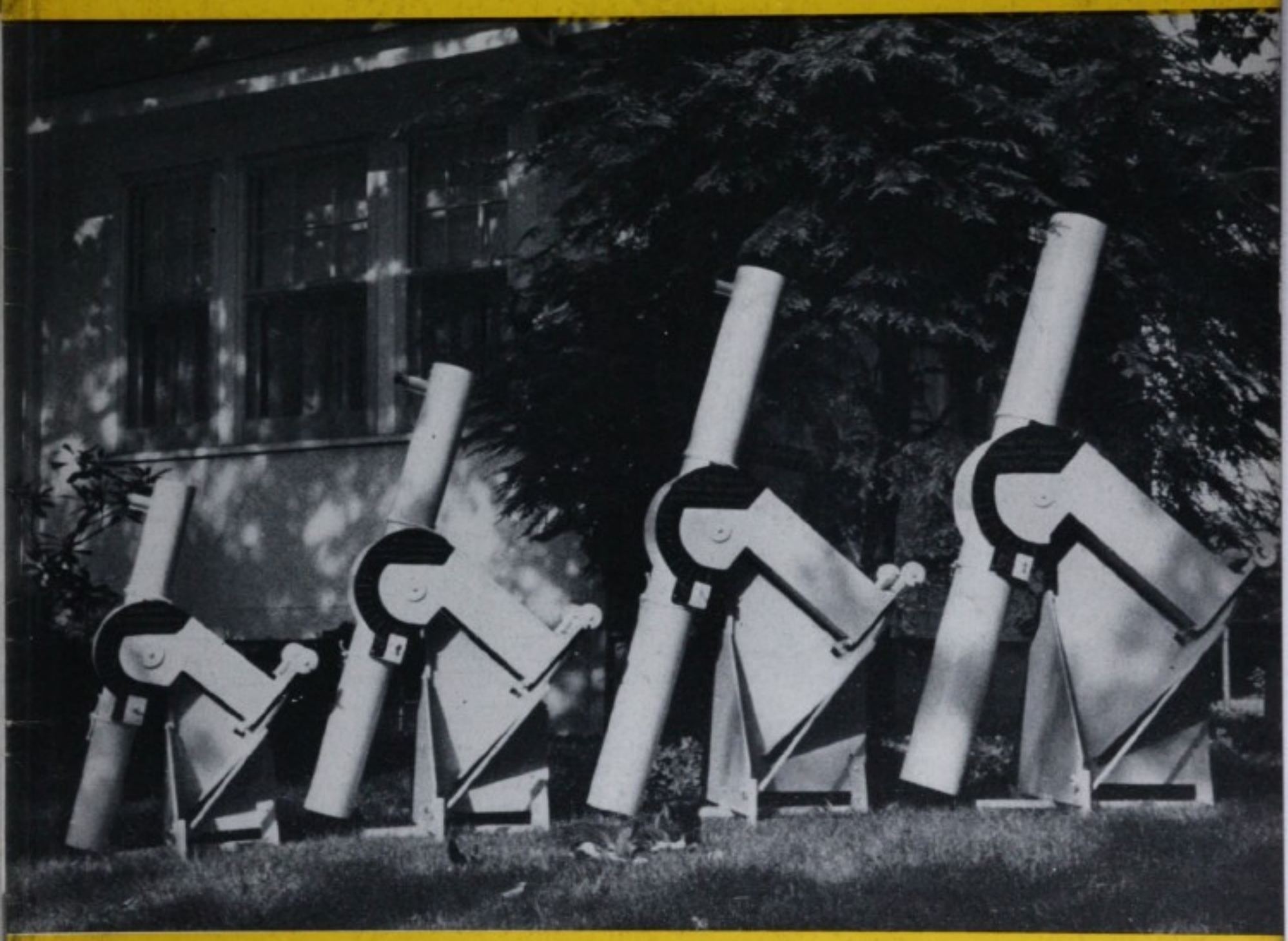
Sky and TELESCOPE



A family of telescopes

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Vol. XII, No. 8

JUNE, 1953

Whole Number 140

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Stones from the Sky?

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NEW PRECISION OSCILLATOR

Eclipse observers, usually in need of high-precision clocks, will welcome a new portable continuously oscillating frequency standard recently developed by Peter G. Sulzer, of the National Bureau of Standards. With accuracy it combines small size, low weight, and easy temperature control.

Fitting into a tube less than two inches in diameter and seven inches long, the major components of the new transistor oscillator are a type 2517 junction transistor, a high-precision 100-kilocycle GT-cut quartz crystal unit, and a long-life mercury cell. Operating at 1.35 volts at 100 microamperes, the dry-cell power supply should have an active life of five or more years.

Over half of the space in the tube is occupied by the crystal, which is mounted in an evacuated glass envelope. The transistor, coil, capacitors, and resistors are supported on a bakelite frame that may be "potted" in casting resin to add rigidity to the section. The mercury cell, only about one-half inch deep, is at the base of the assembly and is insulated from the metal "can" by a bakelite shield. A constant phase shift in the feedback loop associated with the crystal is obtained by using large, stable "swamping" capacitors at both crystal connections and by means of highly stable components in the remainder of the circuit. Constancy of amplitude of oscillation is achieved by operating the transistor in such a manner that collector-voltage limiting is produced. The diagram shows the manner in which the 100-kilocycle tank circuit voltage is reduced by means of an attenuator.

Over short intervals, time variations of about three parts in 10^{10} have been found in the oscillator, and the drift in 24 hours is about three parts in 10^9. These figures are comparable to those obtained from vacuum-tube standard oscillators, particularly at the time of their initial installation; frequency drift normally decreases with age. The change in frequency is about one part in 10^8 per 0.10-volt variation in the supply voltage.

In the field it is always difficult to control the temperature of equipment. Standard quartz oscillators and quartz clocks have heretofore required relatively complex temperature control apparatus (operating at temperatures up to 60° centigrade). With a change in temperature of one degree, the new oscillator's frequency may vary one part in 10^8, but reasonable stability can be achieved by merely placing the oscillator in a Dewar flask containing crushed clear ice (0° centigrade). Thus, it now becomes possible to carry this frequency standard anywhere in the world. D.H.

Sky and TELESCOPE

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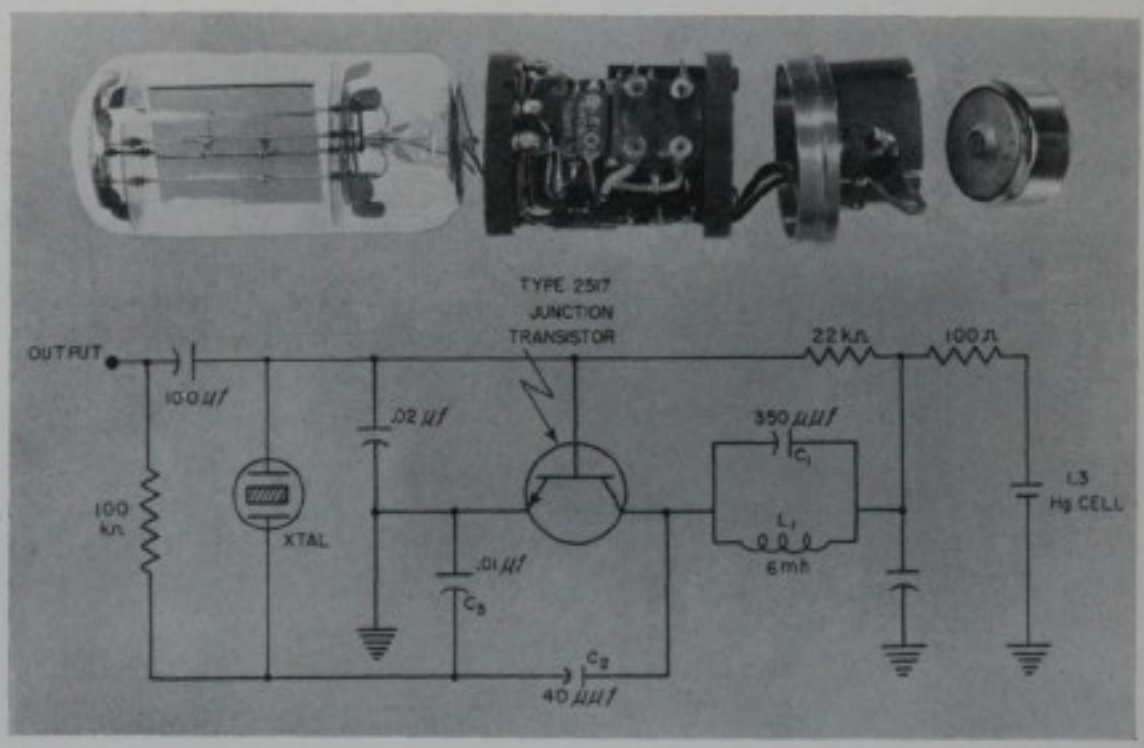

Components and circuit of National Bureau of Standards transistor oscillator.

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BACK COVER: The total solar eclipse of February 25, 1952, photographed at Khartoum, Anglo-Egyptian Sudan, by Dr. G. Van Biesbroeck, of Yerkes Observatory, University of Chicago, for the purpose of checking the Einstein shift of starlight passing the sun. The plate was exposed 1½ minutes through a yellow filter on Eastman 103a-E emulsion, with maximum sensitivity around 6500 angstroms, for which wave length the lens was computed. The print was made with a specially cut rotating sector to procure proper rendition of both the bright inner regions and the faint outer extensions of the corona, which required a difference of 100 in exposure time. Note the fine structure of the fan-shaped polar spikes, and the very long equatorial streamers typical at sunspot minimum. Photograph, courtesy National Geographic Society.

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The new distance scale of the universe places the Great Nebula in Andromeda at a distance of about 1,500,000 light-years, and increases its known size to somewhat more than that of our own Milky Way system. This photograph of M31 and its companion galaxies was taken with the Jewett Schmidt telescope of Harvard Observatory.

THE DISTANCE SCALE OF THE UNIVERSE -- I

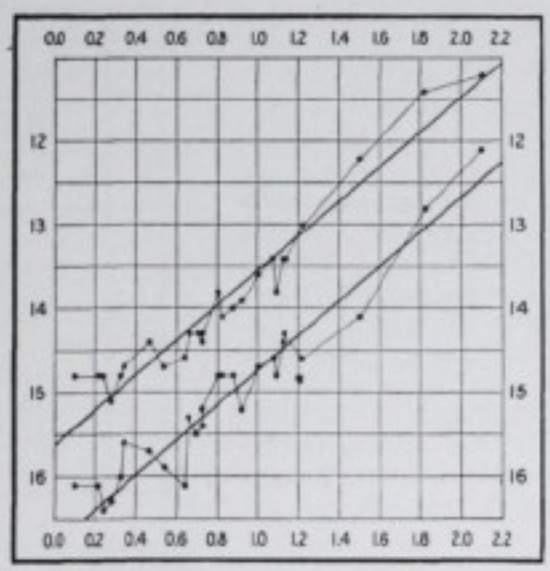
By Otto Struve, *Leuschner Observatory*
University of California

THE YEAR 1952 will go down in astronomical history as one in which astronomers accepted a tremendous change in their concept of the distance scale of the universe. Also, it will mark an astronomical milestone that we have reached directly as a result of observations with the 200-inch Hale telescope — observations which no other instrument in the world is capable of making. The significance of this change is concisely described in the following paragraph quoted directly from the official minutes of Commission 28, Extragalactic Nebulae, of the International Astronomical Union, at its Rome meeting, September 4-13, 1952:

"Dr. Baade then went on to describe several results of great cosmological significance. He pointed out that, in the course of his work on the two stellar populations in M31, it had become more and more clear that either the zero point of the classical Cepheids or the zero point of the cluster variables must be in error. Data obtained recently — Sandage's color-magnitude diagram of M3 — supported the view that the error lay with the zero point of the classical Cepheids, not with the cluster variables. Moreover, the error must be such that our previous estimates of extragalactic distances — not distances within our own galaxy — were too small by as much as a factor 2. Many notable implications followed immediately from the corrected distances: the globular clusters in M31 and in our own galaxy now come out to have closely similar luminosities; and our galaxy may now come out to be somewhat smaller than M31. Above all, Hubble's characteristic time-scale for the universe must now be increased from about 1.8×10^9 years to about 3.6×10^9 years."

In the final analysis, our knowledge of the distances of stars and galaxies rests upon the determination of the scale of the solar system; for several hundred years astronomers have been concerned with this first stage of the problem, until now we know solar system distances with good accuracy. Then, using as a base line the astronomical unit, that is, the distance between the earth and the sun, astronomers succeeded in 1837 in measuring the parallactic displacement and, hence, the distance of one of the nearest of the stars. The trigonometric parallax determinations which followed in the next 116 years form the second stage in the exploration of the universe.

The third stage resulted from Miss H. Leavitt's discovery, in 1912, of a close relation between the apparent brightnesses and the periods of Cepheid variable stars in the Small Magellanic Cloud. From a study of 25 variables, she made a diagram in which the apparent magnitude of each star at maximum and at minimum light was plotted against the logarithm of the period. A variable with a period of exactly 10 days would have a logarithm of the period equal to 1.0 and would, according to the diagram, appear on a photographic plate with an apparent magnitude of 13.5 when at maximum light and about 14.7 when at minimum light. Fainter variables were found to have shorter periods;



The original period-luminosity curve, copied from Harvard Observatory "Circular" No. 173, March 3, 1912, in which Miss Leavitt's discoveries are described.

those of magnitudes between 15 at maximum and about 16.5 at minimum correspond to a period of about one day.

This diagram was the beginning of all our recent knowledge concerning the distances between our galaxy and other galaxies such as the Andromeda nebula, M31, and the great spiral in Triangulum, M33. Although at the time Miss Leavitt made this discovery, the importance of the period-luminosity relation for distance measurements was not appreciated, either by her or by E. C. Pickering, then the director of the Harvard Observatory, Miss Leavitt did remark:

"Since the variables are probably at nearly the same distance from the earth, their periods are apparently associated with their actual emission of light, as determined by their mass, density, and surface brightness. . . . Two fundamental questions upon which light may be thrown . . . are whether there are definite limits to the mass of variable stars of the cluster type, and if the spectra of such variables having long periods differ from those . . . whose periods are short."

It should be realized that Miss Leavitt's diagram as such did not directly

The Small Magellanic Cloud, in which are contained the variable stars used by Miss Leavitt to discover the period-luminosity relation. Harvard Observatory photograph.

provide the means for determining distances. It merely showed, for instance, that a Cepheid whose period is 10 times longer than that of another variable of this kind is approximately two magnitudes brighter than the latter. Two magnitudes correspond to a difference in intrinsic luminosity of 6¼ times. Thus, if we observe two variable stars of the same apparent magnitude at maximum light, the one having a period of four days, the other of 40 days, we can conclude that the longer-period variable is 6¼ times as bright but considerably farther away. As brightness varies inversely with the square of the distance, the actual relative distance would be the square root of 6¼, or about 2½ times; the star of longer period must be 2½ times as distant as the one of shorter period.

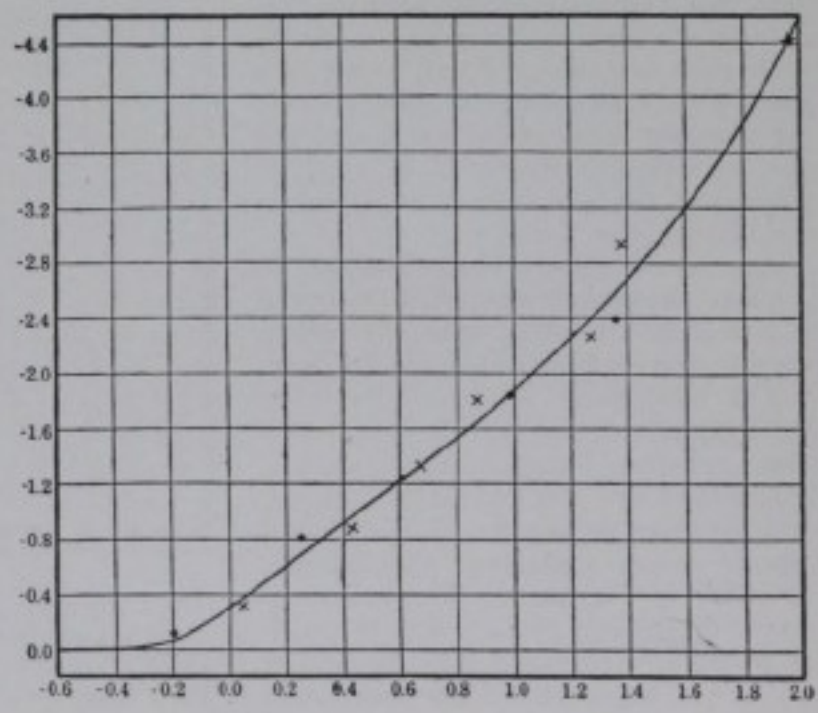
But if we have not yet determined the distance of the nearer star, our observation provides only relative distances and does not give us any information regarding the absolute scale of distances. This latter and important aspect of the period-luminosity relation of the Cepheid variables is usually described as setting the zero point of the period-luminosity curve.

The extension of Miss Leavitt's work and its practical use as a yardstick for measuring the distances of globular clusters and extragalactic systems was made by H. Shapley in a long series of papers published in the *Astrophysical Journal* more than 30 years ago, while he was a member of the Mount Wilson Observatory staff. In some of his early work he determined the zero point, although this had also, in effect, been done by E. Hertzsprung in 1913 on the basis of the Boss proper motions for typical Cepheids.

If we could measure trigonometrically the distance of a single Cepheid variable star in our Milky Way system, and if we could estimate the amount of interstellar absorption between us and this variable star, we would have an immediate determination of the zero point. Unfortunately, even the brightest of the Cepheid variables are so far away that ordinary trigonometric parallaxes are useless. Nor is there any indirect method available of the kind astronomers use when they take advantage of a special type of star occurring as a member of a visual binary system. Cepheid variables do not even occur among moving clusters of stars, such as the Hyades, or among other galactic clusters, like the Pleiades, for which the distances can be estimated with the help of the Hertzsprung-Russell diagram (*Sky and Telescope*, May, 1951, page 164). We are left with the difficult method of estimating statistically the distances of certain groups of galactic Cepheids with the help of their radial velocities and proper motions.

The method is, in principle, quite simple. Suppose you are located on a high building and you watch the movement of persons in the streets below. Suppose you know that the average speed of a person walking is one yard per second; you will also know that some persons are walking considerably faster than the average and others much slower. Therefore, you observe some of them to change their positions hardly at all, while others appear displaced about 20 degrees in 10 seconds. Between these extremes there are individuals that appear to move with various speeds, and you conclude that their average apparent displacement is 10 degrees in 10 seconds or one degree in one second. You would further conclude that, on the average, a displacement of one degree per second corresponds to the known average linear velocity of one yard per second. In other words, at your distance above the street, one yard subtends an angle of one degree; from this you can easily compute that your elevation is about 60 yards.

The apparent angular motions of the bright Cepheid variables have been determined from accurate measures of

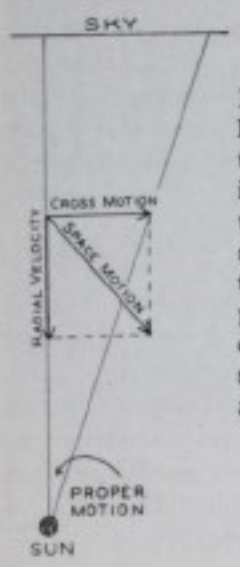


The photographic period-luminosity relation adopted by Harlow Shapley in his book, "Star Clusters," 1930. The dots represent means for intervals of logarithms of the periods; the crosses, for intervals of absolute magnitude.

their positions in the sky extending over hundreds of years. For the same stars, motions in the line of sight, or radial velocities, have been determined from measures of the Doppler shifts of their spectral lines. An individual Cepheid, however, may be moving only at right angles to the line of vision, thus having large proper motion and no radial velocity with respect to the earth. Another star could be moving entirely along the line of sight, and would then have no detectable proper motion or tangential velocity. For an individual star we cannot determine whether a small proper motion results from an actual small velocity at right angles to the line of sight, or whether the motion seems small because the star is very far away. But if we consider the problem statistically, we may assume the motions to be at random, as large a component being radial as tangential, and we may roughly equate the radial and linear tangential velocities. On this basis, the measured radial velocity should be approximately a measure of the linear motion of the star, while the angular proper motion should be a measure of this same velocity as seen from the distance between the earth and the star. Thus, if a star of large radial velocity has a small proper motion, its distance must be relatively great; stars of larger proper motion must be nearer.

The mathematics of this process is not difficult to understand, but it is unnecessary for our present purpose. The important point is to realize that if, over a large statistical sample of stellar data, we grant the similarity of the radial and tangential velocities, relatively reliable statistical parallaxes may be obtained.

In this manner, Shapley set the zero point of his famous period-luminosity curve, in which the abscissa has the same meaning as in the period-luminosity relation of Miss Leavitt, but the ordinate now represents the intrinsic or absolute photographic magnitudes of the variable stars half way between maximum and minimum light. This diagram, therefore, gave us a means of determining the individual distances of the Cepheid variable stars once we observed their periods.



Here is shown the relation among cross motion (tangential velocity), radial velocity, and the space motion of a star. Proper motion is the angular change of position produced by the cross motion, but its observed value depends also on the distance of the star.

The Large Magellanic Cloud, pictured here, and the Small Cloud are now considered to be at a distance of about 150,000 light-years, or 1/10 as far from the earth as the Great Nebula in Andromeda. Harvard Observatory photograph.

Let us suppose that in our galaxy we have observed a variable star whose apparent magnitude, half way between maximum and minimum light, is +8.2. After a series of observations we find that the period is 10 days. Taking the logarithm of the period, namely 1.0, and entering with it Shapley's diagram, we read off the ordinate scale that the absolute magnitude of the variable is −1.8. The star thus appears 10 magnitudes fainter when actually observed on a photographic plate than it would be if it were located at the standard absolute magnitude distance of 10 parsecs or 33 light-years. A difference of 10 in magnitude corresponds to a ratio in light of 10,000. Since light intensity diminishes with the square of the distance, the real distance of this variable is 100 times greater than 10 parsecs and is thus equal to 1,000 parsecs.

Since we know that interstellar absorption tends to make the stars look fainter than they would otherwise, we have to introduce a correction to the observed apparent magnitude, allowing for intervening dust and gas, and thus reducing the distance somewhat.

This method is perfectly straightforward, and it was used successfully at Mount Wilson by E. P. Hubble and all of his followers in determining the distances of the nearer galaxies. In these systems many Cepheid variables were discovered, their periods were determined, and the rest of the procedure resembled the example we have worked out in the preceding paragraphs.

In this manner Hubble, in 1929, found that Cepheids of corresponding period in the Andromeda galaxy are about 4.6 magnitudes fainter than in the Small Magellanic Cloud. This would make the distance of the Andromeda galaxy 8½ times greater than the distance of the cloud. Using Shapley's value of 106,000 light-years for the cloud, Hubble set the distance of the Andromeda galaxy as 900,000 light-years.

Except for a relatively minor correction in this figure — bringing it down to 750,000 light-years—which is due to the small amount of interstellar absorption in the direction of Andromeda, this result remained generally accepted until Baade's report at the Rome meeting. Not only that, but all other extragalactic distances were tied to the distance found by Hubble with the help of the Cepheid variables. Hence, the framework of the metagalactic system rested entirely upon Shapley's zero point of the period-luminosity law.

Next month we shall see how the necessity to change the zero point had become increasingly apparent, and how the 200-inch telescope demonstrated the need to change our concept of the size of the universe by a factor of two.

(To be concluded)

NEWS NOTES

By Dorrit Hoffleit

LUNAR PROFILES FROM A BEADED ECLIPSE

The solar eclipse of May 9, 1948, was annular, with 0.9996 of the sun's diameter eclipsed as seen from Rebun Island, Hokkaido, Japan. Thus at maximum phase little more of the sun could be seen than Baily's beads around the whole perimeter. Over 200 separate beads were observed. In the *Publications* of the Astronomical Society of Japan, Shigetsugu Fujinami, of Kyoto Observatory, describes how times of contacts at this eclipse were utilized for the determination of the heights of some of the mountains and depths of deep valleys at the limb of the moon.

Moving pictures at the rate of 24 frames a second for an interval of one minute bracketing the maximum phase were taken with a Cassegrain reflector with a focal length of 1,400 millimeters. For the first and last contacts the exposures were f/18, 1/432 second, and during the beaded phases f/15, 1/50 second. Time markers were printed along the film sound track at half-second intervals to an accuracy better than 0.02 second. The times of contact could readily be reduced to heights above a mean lunar limb. Such contour data have ordinarily been obtained from measurements of photographs of the moon, and standard results are available in Friedrich Hayn's *Selenographische Koordinaten* (1914).

Fujinami finds that many of the mountains are appreciably higher and the valleys deeper than the older tables indicate. Moreover, analyzing the relative accuracies of the methods for determining the jagged lunar profiles, he is convinced that the eclipse method is substantially more accurate. Hayn's data are given to the nearest 1/10 second of arc and Fujinami's to hundredths. Numerous conspicuous features observed by both differ by 0.5 second or more. The most outstanding discrepancies found are for the depressions d'Alembert, Rook, and Mare Humboldtianum, respectively 2".48, 2".34, and 1".29 deeper than previously thought, and the mountain d'Alembert, which is 0".68 higher. Irradiation on photographs would appear to account for a smaller range of altitudes than that obtained from accurate time determinations. It will be of interest to see how Fujinami's results compare with photoelectrically determined profiles being obtained by C. B. Watts at the U. S. Naval Observatory.

IRISH SOLAR ECLIPSES

For the benefit of those concerned with chronology, F. J. O'Connor, of the Dunsink Observatory, has compiled in the *Proceedings* of the Royal Irish Academy a list of solar eclipses visible from Ireland between A.D. 400 and 1000. During this interval, there occurred a total of 1,421 eclipses of the sun visible from anywhere on the earth. Of these, 862 could immediately be eliminated as altogether invisible from Ireland.

For the remaining 559, the maximum phase was visible from Ireland in 165 cases, and in 28 more cases the sun could be seen after sunrise or before sunset at least 0.2 eclipsed. Thus, from an area of about 32,000 square miles, portions of 193 solar eclipses could definitely be seen out of a total of 1,421 in 600 years.

AWARD TO BART J. BOK

For a paper entitled, "Studies of the Southern Milky Way," Dr. Bart J. Bok, of Harvard Observatory, has been awarded the Lewis prize of the American Philosophical Society. Read at the society meeting on November 9, 1951, the paper deals with the equipment of the Boyden station at Bloemfontein, South Africa, the major programs of the work then in progress, and the results of Dr. Bok's 1½ years sojourn at that observatory. Analysis of the data that were accumulated during this relatively short period, when Dr. Bok's major function was to install and test the Armagh-Dunsink-Harvard telescope, will occupy his assistants for several years.

CHLORINE IN METEORITES

Several years ago, A. Gatterer and V. Frodl reported in *Ricerche Spettroscopichi* (a Vatican publication) on a spectroscopic technique for analyzing very minute amounts of nonmetallic substances by means of an electrodeless high-frequency discharge method.

In a current number of the same journal, E. Salpeter, of Cornell University, describes the application of this technique to the determination of the amount of chlorine in stony meteorites. He finds it eminently satisfactory: "... especially suitable for routine analyses and for cases when only a small amount of material is available." Twenty meteorites examined gave an average chlorine content of 0.09 per cent to an accuracy of 10 per cent. This value is in good agreement with previous determinations for stony meteorites.

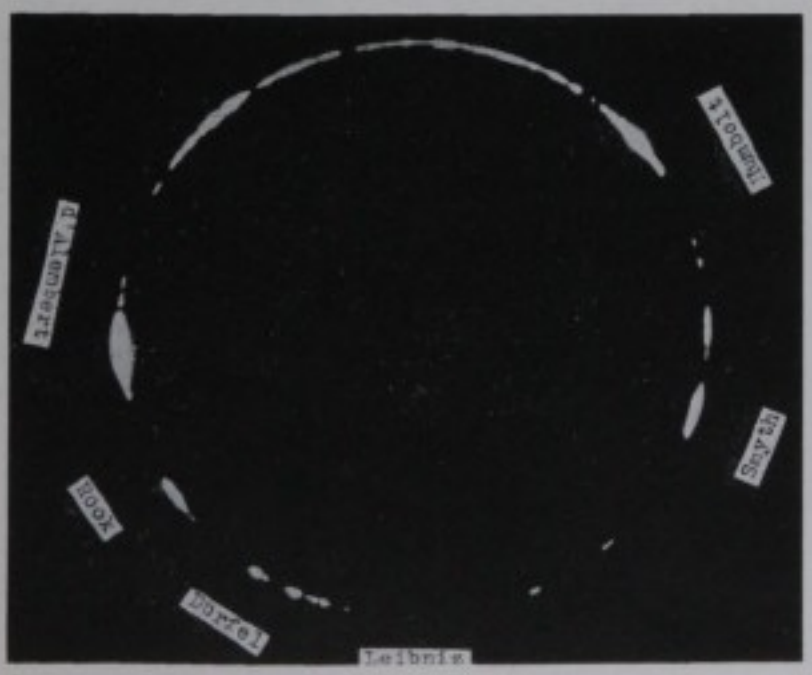
CHLOROPHYLL FORMATION

The chemical basic to most forms of life, chlorophyll, could have been spontaneously created in the lifeless world of two billion or more years ago, according to Science Service, reporting the results of experiments at Ohio State University under the direction of Dr. William M. MacNevin. When carbon dioxide, ammonia, and water were passed over a heated silica tube (representing the hot rocks of the earth's early days), molecules of porphyrin were produced; this substance has a basic structure like that of chlorophyll.

In another experiment re-creating conditions in the earth's youth, artificial lightning was sent through an atmosphere of marsh gas (methane) and water vapor. It is believed that lightning was almost continuous in the atmosphere of the cooling earth. The experiment resulted in the formation of a resinous substance so complex chemically that its structure could not be analyzed.

NATURAL NEPTUNIUM 237

In 1947, Nobel prizewinner Glenn T. Seaborg predicted that the isotope of neptunium of atomic weight 237, first discovered with the Berkeley cyclotron in 1942, would be found in nature in minute quantities. This prediction has now been fulfilled by its discovery in ores in the Belgian Congo.



The middle of the annular eclipse of May 9, 1948, as it was photographed by a Kyoto Observatory expedition to Rebun Island. The limb features named are those for which large discrepancies in height or depth are found when compared with Hayn's data.

Wilkie Observatory

By D. C. Dornberg

A NEW OBSERVATORY, housing an 8-inch reflecting telescope, has been added to Macalester College, St. Paul, Minn. The cost of the instruments and dome, with their operating mechanisms, was borne by the Wilkie Foundation. The Continental Machine Company, of Savage, Minn., one of the sponsors of the foundation, built the main telescope, the optics of which are by R. E. English, of St. Paul. Macalester College constructed the building.

Dr. W. J. Luyten, professor of astronomy at the University of Minnesota, is teaching the first course in astronomy. The Wilkie Observatory is under the direction of Dr. Waldo Glock, chairman of the department of geology and astronomy at Macalester.

Two consultants for maintenance and future development of the observatory were appointed by the college, Mr. English and the writer, who will teach an evening class in popular astronomy at the college. We are members of the St. Paul Telescope Club, as is Dr. Glock.

The ground floor of the new building is pear shaped and measures approximately 16 by 32 feet, the small end pointing east. The 12-foot dome rests on 8-inch reinforced concrete slab supported by crossed 8-inch I-beams.

Dr. Waldo Glock, chairman of the department of geology and astronomy at the college, is here adjusting the right-ascension drive of the 8-inch reflector.

Five smaller telescopes of 60 power each can readily be fastened to the observation platform railing east of the dome. These are used for student instruction, permitting a number to observe at one time.

The main telescope is an 8-inch Newtonian-Springfield of 64-inch focal length; it is equipped with a 20-power finder. The telescope pier is made of 8-inch welded steel pipe and rests on the intersection of the I-beams. Spindles 2½ inches in diameter support both the right-ascension and declination axes, serving as the bearings. The spindles were made a few 10-thousandths of an inch under size and were then chrome plated and lapped in. Thus, the fit allowance of the spindles is less than 5/10,000 of an inch.

The setting circles are machine-indexed 10-inch disks of chrome-plated steel. A 1/20 horsepower synchronous motor turns the right-ascension movement once in 24 hours. Thus, the telescope tracks at a mean solar instead of a sidereal rate, which is satisfactory for an instrument used primarily for instruction.

The Wilkie Observatory at Macalester College, which was dedicated in October, 1952. Note the 60-power telescopes on the railing of the outdoor observing platform. The entire first floor of the building is a classroom.

SHORT-PERIOD VISUAL BINARY

By means of an interferometer attached to the eyepiece of the 26½-inch refractor of the Union Observatory at Johannesburg, South Africa, W. S. Finsen has been conducting a survey for visual double stars so close together that they appear as one except when resolved into two stars by the interferometer technique. In the course of his survey, Dr. Finsen has now found the star Epsilon Ceti to be double, and in the February number of the *Monthly Notes* of the Astronomical Society of South Africa he gives a provisional orbit.

The period indicated, 1.59 years, is shorter than that of any other visual binary except Capella (an interferometric binary which has a period of only 105 days). The next shortest visual binary period is 1.715 years, determined by G. P. Kuiper for the star BD −8°-4352. Dr. Finsen is cautious in announcing his results, for they depend on only 21 observations spanning an interval of only slightly more than two years; some ambiguity in the interpretation of some of the measured position angles is possible. The star is very deserving of further investigation.

Student Observations of Delta Cephei

By Peter van de Kamp
Sproul Observatory, Swarthmore College

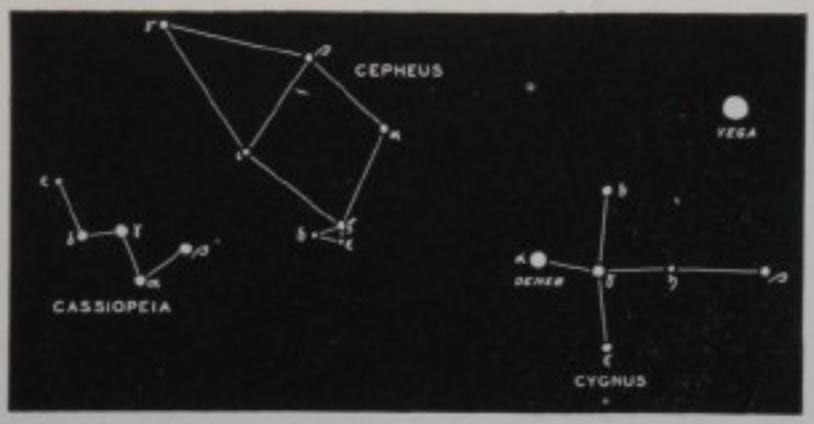


Fig. 1. The location of Delta Cephei.

THE VARIABLE STAR Delta Cephei is well suited to give elementary astronomy students the satisfying experience of observing a celestial object whose brightness varies from night to night.* The star is easy to find, and is sufficiently bright even at minimum; it has a moderate range in brightness and an interesting, asymmetrical light curve. A few weeks of observations usually suffice to suggest to the observer that the star goes through a regular cycle of light variation. A few months permit a determination of the period of variation and give further insight into the light curve.

The prototype of the Cepheid variables is in an extremely favorable position for observers in the Northern Hemisphere. Observations may be made in the evening during the first half of the usual academic year. By the end of January, the star gradually disappears into the evening twilight, and both the diurnal and yearly motion of the earth cannot have failed to impress the regular observer.

Delta Cephei is easily located by means of a small isosceles triangle between Deneb (Alpha Cygni) and Cassiopeia (Fig. 1). The base of the triangle is formed by Zeta (ζ) Cephei and Epsilon (ε) Cephei; the vertex, Delta (δ) Cephei, points toward Cassiopeia. Zeta and Epsilon make ideal comparison stars, representing the approximate limits within which the brightness of Delta Cephei varies. The observer may adopt magnitudes for Zeta and Epsilon (for example, 3.60 and 4.36, respectively, from the Potsdam *Durchmusterung*), and from night to night assign an estimated magnitude to the variable star. A better procedure is to adopt a scale of, say, 10 steps between Zeta and Epsilon and to estimate Delta on this scale.

At Swarthmore, for several years now, we have used the following scheme. The magnitude grade A is assigned to Zeta Cephei, the magnitude grade E to Epsilon Cephei. The brightness of Delta is estimated on the scale A, B, C, D, E, and intermediate grades are also assigned; one-half grade is close to 1/10 magnitude. Using this grade system, there has never been any confusion as to which symbol stands for the bright and which for the faint comparison star. The variable is never estimated brighter than A; however, occasional estimates below E are made. There is some personal equation between the range in observed grades for different individuals; color equation probably plays a role. Zeta Cephei, of spectral type *K*0, is redder than Epsilon, of type *F*0, while Delta is redder at minimum than at maximum.

Starting early in October, by January an industrious student will usually have made up to 60 observations, or even more. Each evening only one observation is made, and its comparative certainty is noted in relation to the observing conditions (clear, haze, moon, and so forth). The time is recorded, perhaps to within five minutes. This is done as a matter of observing policy, rather than necessity. The times of the night may be neglected, and only the days considered, since it is quite evident that Delta does not vary noticeably during the course of one evening. The observations are plotted, using brightness as ordinate and date as abscissa (Fig. 2). Unless the number of observations is woefully inadequate, their cyclic nature should be evident after several weeks, with a number of apparent maxima and minima. As a rule, observations marked A, A-B, and possibly B, are considered as having been made near maxima. Similarly, those marked E, D-E, and perhaps D, are considered to be near minima. To analyze the observations for periodicity, a count is made of the number of days between successive maxima, and also between successive minima. These intervals cluster around values of the period and multiples thereof. An approximate value of the period may now be estimated, and it becomes possible to assign order numbers to the maxima and also to the minima, since the observer can allow for the missing maxima and minima that were not covered by the observations.

A continuous curve is then drawn, passing close to the observations, also tentatively through those parts of the plot where there are no observations but where the approximate trend of the brightness may be inferred from the cycle indicated by the observations. It should be kept in mind, however, that for a variety of causes individual brightness

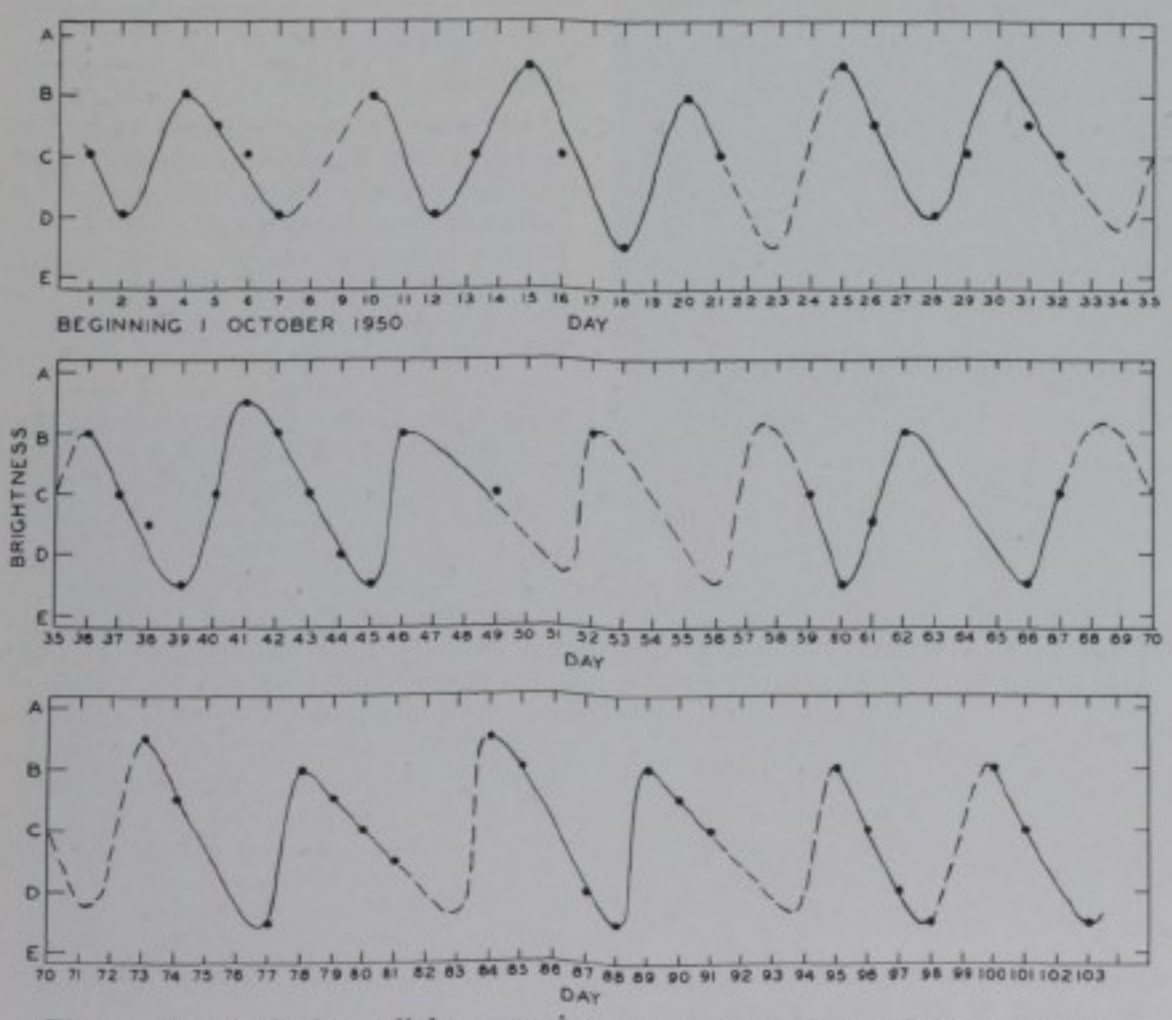


Fig. 2. The preliminary light curve is dashed where observations are absent.

*See also D. B. McLaughlin, **Astronomical Journal, 43**, 113, 1934; J. Texerau, **l'Astronomie, 65**, 481, 1951.

estimates may be off, occasionally as much as one grade or more.

As the period of light variation is assumed to be constant, it is now possible to determine this length of time more exactly. The dates of the observed maxima and minima are listed, by using the days numbered consecutively from the time of the first observation, disregarding months. These numbered dates are referred to as epochs. The period may be determined by comparing the order numbers of the observed maxima and minima with the corresponding epochs. The numbers of these observed maxima are listed and paired off, using each observation only once. On the basis that the greatest accuracy is obtained by pairing two extremes in time, begin by comparing the first and last maxima to get one determination for the period; next, compare the second and the next-to-last maxima, thus obtaining another determination, and so on. The minima are handled similarly.

The conditional equations are of the form $Pn = I$, where P is the period, n the number of cycles, and I the elapsed interval. Obviously, those determinations that are based on the greatest time intervals are most accurate. In accordance with the theory of errors, we weight the observations in proportion to the square of the number of periods; putting it more technically, we derive normal equations both for maxima and for minima, as follows:

$$P\Sigma n^2 = \Sigma In$$

The actual method of using these equations is illustrated on page 212.

Proceeding in this way, we find that values of the period derived independently from the maxima and minima usually agree within 0.1 day. If we wish, we may add the normal equations covering both maxima and minima, and thus get one simple normal equation, yielding one final determination of the period, which usually is calculated to 0.01 day, although it may be off by several hundredths of a day.

The adopted period is now used to reduce all observations to one cycle covering one whole period. Assuming that the pattern of light variation of Delta Cephei is alike in all its cycles, we may superimpose these cycles into one cycle to show their average behavior. This is done by selecting, for example, the first cycle, and reducing all subsequent observations to this first cycle. For any observation in the second cycle subtract the period from the observed epoch, and plot the observed brightnesses for the epochs thus reduced together with the first-cycle observations. For the third cycle, subtract twice the period from the observed epochs, and so on for additional cycles. Integral multiples of the period are subtracted from the epochs of all succeeding observations, in order to place them within the first cycle, always carrying out the calculation to 0.01 day. When all observations are plotted this way, the numerous individual observations, each reduced to its corresponding "phase" in the first cycle, show the general pattern of variability (Fig. 3).

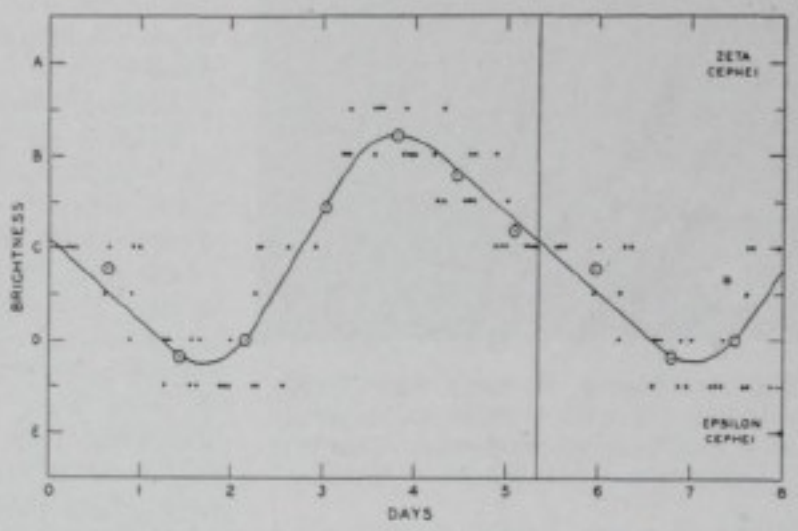


Fig. 3. The smoothed light curve, obtained after the observations have been reduced to a selected cycle, and after a number of normal points have been determined by averaging observations within selected intervals.

The observations normally show a healthy scatter, and there probably will be a few high residuals. The pattern of the light curve can be seen more clearly if the cycle is divided into several phase intervals, containing approximately equal numbers of observations (say anywhere from four to 10), and an average point is found within each segment. The range in phase should be sufficiently small lest the shape of the light curve be distorted by averaging observations over too wide a time interval. The grades A, B, C, D, and E, may be replaced by the numbers 4, 3, 2, 1, 0, and averages formed of the grades (ordinates) and phases (abscissae) of all the points within each segment. The average grade and phase in each segment determines the average point, the so-called normal point for that segment. These normal points represent a condensed summary of the observations and their analysis for periodicity.

A smooth curve may be drawn which closely follows the normal points. Care should be taken that approximately equal numbers of observations are above and below the final smooth curve. This procedure will confirm what may already have been indicated by observations within individual cycles, namely, that there is a difference in the slopes of the ascending and descending portions of the curve. It will also be found that the maximum brightness of the light curve is not as bright as A and the minimum not as faint as E; in other words, observations denoted A and E represent exaggerations of the true brightness range. This is not surprising, since observing errors of a whole grade or even larger do occasionally occur. The more advanced student may wish to study the distribution of the individual residuals from the "final" light curve. If desired, the period may be further improved from an analysis of the intermediate estimates, since now it can be decided which fall on the ascending and which fall on the descending branch of the light curve.

This project is an interesting experiment in observation and analysis. The student, in common with the professional, is often disappointed at the size of the residuals, and may be tempted to discard observations. With very few exceptions, which should be carefully documented, and apart from having no ethical foundation, this procedure is futile. Generally speaking, no improvement is reached by discarding large residuals; rejection of the largest residual will leave a next largest residual, and so on. As a rule, the only way to improve a series of observations of this kind is to add more observations.

(Example on page 212)

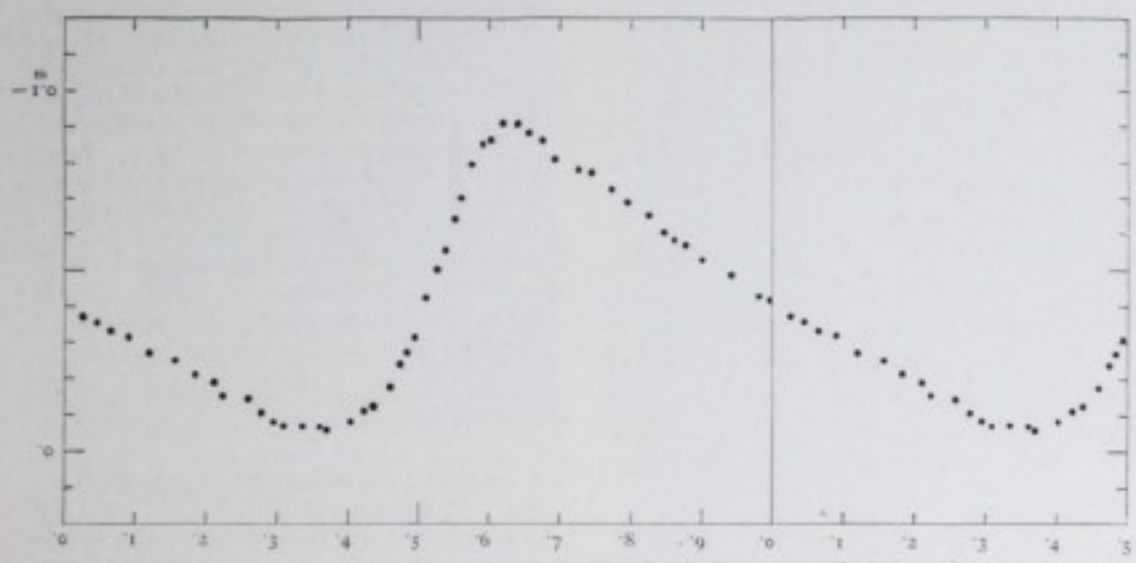


Fig. 4. A photovisual light curve of Delta Cephei, by A. J. Wesselink, reproduced from the "Bulletin" of the Astronomical Institutes of the Netherlands, 1946.

Stones from the Sky?

By Helmut Heckscher

The appearance of some very bright meteors was once thought to be purely an atmospheric phenomenon. This is a 19th-century drawing of a fireball.

VISITORS from outer space? Incredible! "Physically impossible," was the conclusion of Professor P. Bertholon, one-time editor of the *Journal des Sciences*. And the accounts themselves? "Evidently untrue."

Quite so, agreed the editor of the *Décade Philosophie*: These reports are difficult to believe; one would do much better to deny their truth altogether. "Of course," you say today. "These flying saucer stories. . . ."

But Professor Bertholon and his colleagues weren't talking about flying saucers at all. In fact, in the 1790's when these gentlemen made their pronouncements, nothing could have been further removed from their minds than the idea of a ship from outer space. They were talking about other reports, seemingly just as ludicrous, of stones that were said to have fallen from the sky. For example, such an apparently levelheaded man as the mayor of Agen had gone so far as to affix his signature to such an eyewitness account. "How sad it is," wrote Bertholon, "to see a whole municipality verify — by means of a protocol —folklore which one can only pity. . . ."

E. F. F. Chladni, 1756-1827, a German physicist who revived the theory that meteorites were of extraterrestrial origin.

What made it worse, thought Bertholon, was that some other natural philosophers actually were beginning to take these reports seriously. In 1793, for instance, G. C. Lichtenberg, a professor at the University of Goettingen, had suggested to one of his students that certain meteoric phenomena, such as shooting stars, fireballs, and even the stones that were supposed to have fallen, might be of extraterrestrial, "cosmic" origin, and that, in any case, the topic seemed to be an interesting one for speculation. This student, a certain E. F. F. Chladni, with German thoroughness plowed through all the old and musty volumes of the *Philosophical Transactions* and other magazines that contained observations on "fallen masses."

It was all right, perhaps, for this young man to look through old papers, if he liked that sort of thing, but it was a different matter for him to publish his findings the following year. He proposed, with apparent seriousness, that masses of iron and stone had actually fallen from the sky from time to time, that shooting stars and fireballs were basically identical, and that all these bodies had arrived on earth from outer space!

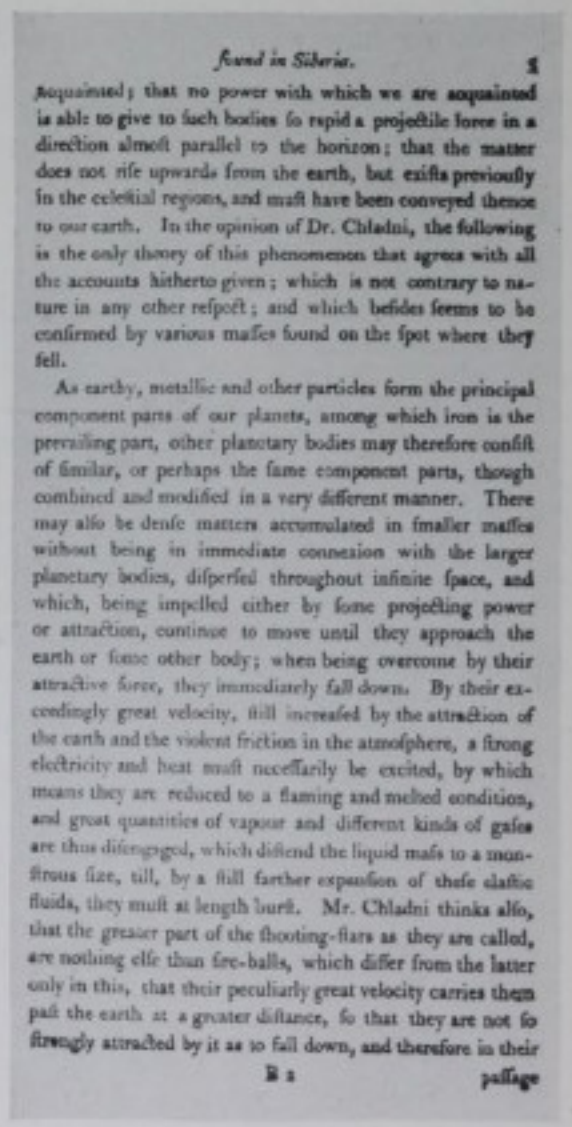
Bertholon and his colleagues could only shake their heads. In ancient times, of course, there had been people like Anaxagoras who claimed that fireballs and the like were cosmic; one could regard these sayings as colorful expressions of primitive myths. But when it came to modern times, to the end of the 18th century, to the age of reason — one could only laugh at Chladni's conclusions.

But more reports began to come in. Only about two months after the publication of Chladni's findings, for instance, a great many stones were observed to fall near Siena in Italy, only about 18 hours after Mt. Vesuvius had erupted. What could be made of this, the Earl of Bristol, who had resided in Siena, asked himself?

"Either these stones have been generated in this igneous mass of clouds which produced such unusual thunder," he wrote to Sir William Hamilton, "or, which is equally incredible, they were thrown from Vesuvius at a distance of 250 miles. . . . The philosophers here incline to the first solution. . . . I am reduced to perfect skepticism."

The event aroused the interest of the scientific world. To investigate the matter, Sir William himself climbed Vesuvius trying to find stones that resembled those that had fallen near Siena, but on the volcano he could find nothing but a thick coat of ashes. The astronomer, H. W. M. Olbers, too, at first thought that the stones had been hurled from the volcano, but discarded this theory when he found that none had fallen near Vesuvius, and that furthermore the Siena stones strongly resembled others that were said to have fallen in earlier times at different places.

Perhaps, Olbers speculated, stones are sometimes thrown from active volcanoes on the moon. Laplace too thought this might be possible, and calculated the



found in Siberia. 1

Acquainted; that no power with which we are acquainted is able to give to ſuch bodies ſo rapid a projectile force in a direction almoſt parallel to the horizon; that the matter does not riſe upwards from the earth, but exiſts previouſly in the celeſtial regions, and muſt have been conveyed thence to our earth. In the opinion of Dr. Chladni, the following is the only theory of this phenomenon that agrees with all the accounts hitherto given; which is not contrary to nature in any other reſpect; and which beſides ſeems to be confirmed by various maſſes found on the ſpot where they fell.

As earthy, metallic and other particles form the principal component parts of our planets, among which iron is the prevailing part, other planetary bodies may therefore conſiſt of ſimilar, or perhaps the ſame component parts, though combined and modified in a very different manner. There may alſo be denſe matters accumulated in ſmaller maſſes without being in immediate connexion with the larger planetary bodies, diſperſed throughout infinite ſpace, and which, being impelled either by ſome projecting power or attraction, continue to move until they approach the earth or ſome other body; when being overcome by their attractive force, they immediately fall down. By their exceedingly great velocity, ſtill increaſed by the attraction of the earth and the violent friction in the atmoſphere, a ſtrong electricity and heat muſt neceſſarily be excited, by which means they are reduced to a flaming and melted condition, and great quantities of vapour and different kinds of gaſes are thus diſengaged, which diſtend the liquid maſs to a monſtrous ſize, till, by a ſtill farther expanſion of theſe elaſtic fluids, they muſt at length burſt. Mr. Chladni thinks alſo, that the greater part of the ſhooting-ſtars as they are called, are nothing elſe than fire-balls, which differ from the latter only in this, that their peculiarly great velocity carries them paſt the earth at a greater diſtance, ſo that they are not ſo ſtrongly attracted by it as to fall down, and therefore in their

B 2 paſſage

A facsimile reproduction of a page from the "Philosophical Magazine" of 1798, in which Chladni speculates on the origin of meteors from outside the earth's atmosphere.

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LXII. *Memoir on the Stones said to have fallen from the Heavens. Read in the French National Institute by* C. VAUQUELIN *.

WHILE all Europe refounded with the report of ſtones fallen from the heavens, and while philoſophers, divided in opinion on this ſubject, were forming hypotheſes to explain the origin of them, each according to his own manner, Mr. Edward Howard, an able Engliſh chemiſt, was purſuing in ſilence the only route which could lead to a ſolution of the problem. He collected ſpecimens of ſtones which had fallen at different times, procured as much information as poſſible reſpecting them, compared the phyſical or exterior characters of theſe bodies; and even did more, in ſubjecting them to chemical analyſis by means as ingenious as exact.

It reſults from his reſearches, that the ſtones which fell in England, in Italy, in Germany, in the Eaſt Indies, and in other places, have all ſuch a perfect reſemblance that it is almoſt impoſſible to diſtinguiſh them from each other: and what renders the ſimilitude more perfect and more ſtriking is, that they are compoſed of the ſame principles and nearly in the ſame proportions.

Before the laſt reſults of the labour of Mr. Howard were known in France, I had employed myſelf on the ſame object; and I have the ſatisfaction to find in his memoir, which has been ſince printed, that they perfectly agree with thoſe which I had obtained.

I ſhould have abſtained from any public notice of an object which has been treated of in ſo able a manner by the Engliſh chemiſt, if he himſelf had not induced me to do ſo during his reſidence at Paris; had not the ſtones which I analyſed been from another country; and had not the intereſt excited by the ſubject rendered this repetition excuſable.

It is therefore to gratify Mr. Howard, to give, if poſſible, more weight to his experiments, and to enable philoſophers to place full confidence in them, rather than to offer any thing new, that I publiſh this memoir. One of the ſtones which I examined was tranſmitted to me by C. Saint-Amans: it fell at Créon, in the pariſh of Juliac, on the 24th of July 1790, about nine in the evening. This ſtone appeared in the air under the form of a fire-ball, which was viſible in almoſt the whole of the ſouth of France. A very

* From the Journal de Mines, No 76.

correct

A facsimile reproduction of a page from the "Philosophical Magazine" of 1803, in which C. Vauquelin discusses the work of Edward Howard in determining the chemical composition of meteorites.

necessary initial velocity of escape.

There were more theories and counter-theories, heated discussions in the scientific periodicals. By the turn of the century a man might still deny the truth of "fallen masses," but he could no longer laugh at the reports — he must give an explanation as to how these reports came about.

Such a man was C. Patrin, who did not believe that stones had ever really fallen from the sky. He read the reports and found them very unreliable. Had there ever been a stone fall witnessed by a reputable natural philosopher? No, always farmers, natives, ignorant village people. But one could argue with Mr. Patrin — these stone falls are so rare that it would be a great coincidence if a natural philosopher happened to be present. And all the accounts agree with one another so much: Almost always a fireball is first seen to move across the sky with great speed; then there is an explosion, and finally the stones are found. A cloud is frequently seen in the sky. Furthermore, Edward Howard in England has analyzed many of these stones and has found that they resemble each other to a remarkable degree.

Mr. Patrin conceded that the observations were not incorrect, but the inferences were, and developed a theory in explanation. The rapidly moving fireball is in reality nothing but a stroke of lightning, as evidenced by the loud report and by the cloud found to hang in the sky. When the lightning strikes the ground it melts it into a stone which is then found, still hot. The ignorant believe that something solid has actually fallen. For some reason or other lightning has a special affinity for certain earths, which it strikes in preference to others, and the likeness of the resulting stones is a necessary consequence.

This was a beautiful theory, but it had to be given up. One could point out that stones also fell on clear, cloudless days when lightning was out of the question, that no stones had ever been found where lightning was actually observed to strike. And later analyses by Mr. Howard showed that many of these stones contained nickel, an element very rare on the surface of the earth.

C. Vauquelin concluded: "The opinion which makes them come from the moon, however extraordinary it may appear, is, perhaps, the least improbable; and if it be true, that no direct proofs can be given of this opinion, it is equally certain that no well-founded reasoning can be opposed to it. The most prudent course to be pursued in this state of things is freely to acknowledge, that we are entirely unacquainted with the origin of these stones, and of the causes which produced them."

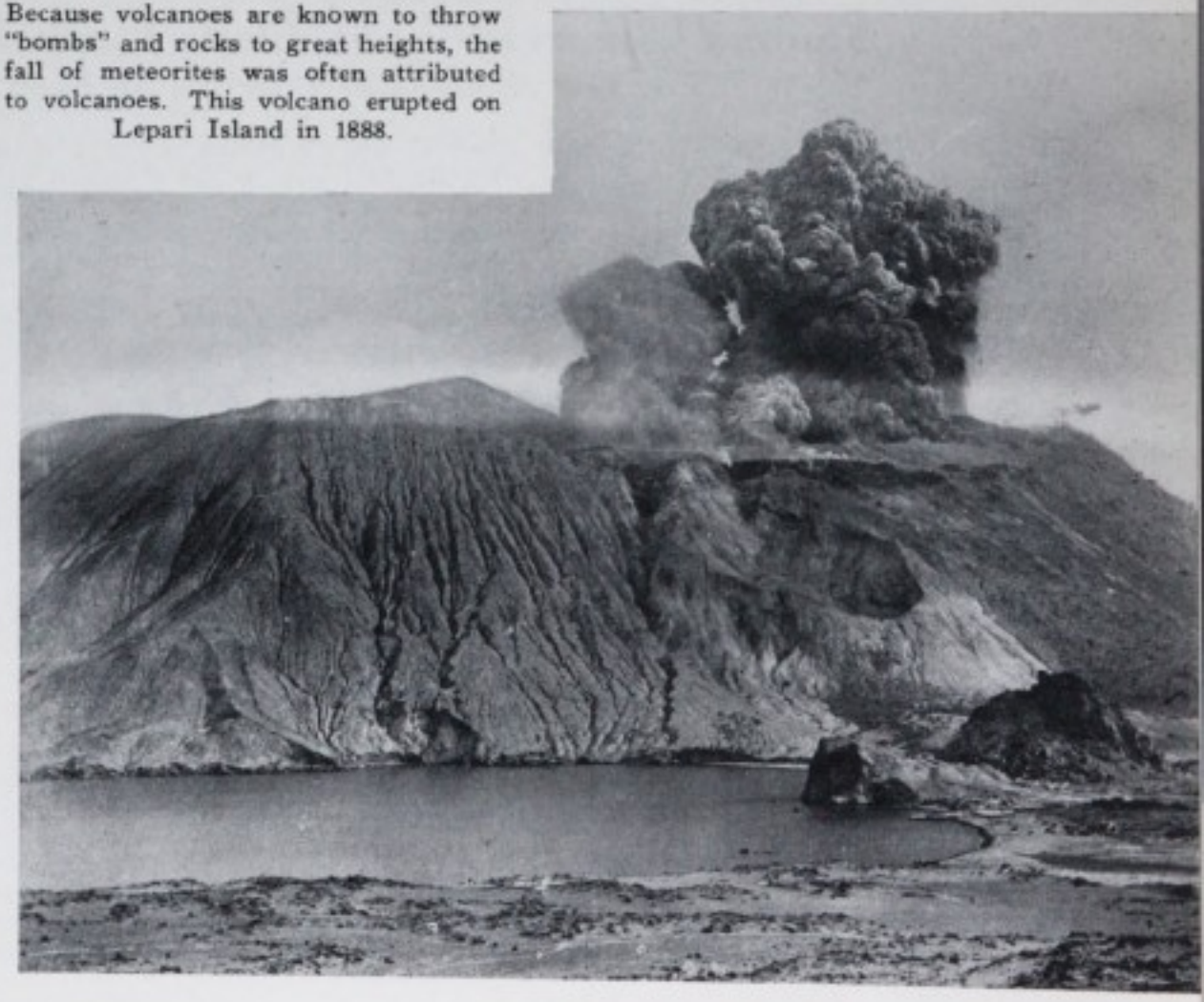
Even Patrin had to admit finally that stones had actually fallen. "The new proofs," he wrote, "leave nothing to be desired." And in the same year, 1803, the French Royal Academy was brought around to the same view by a report by

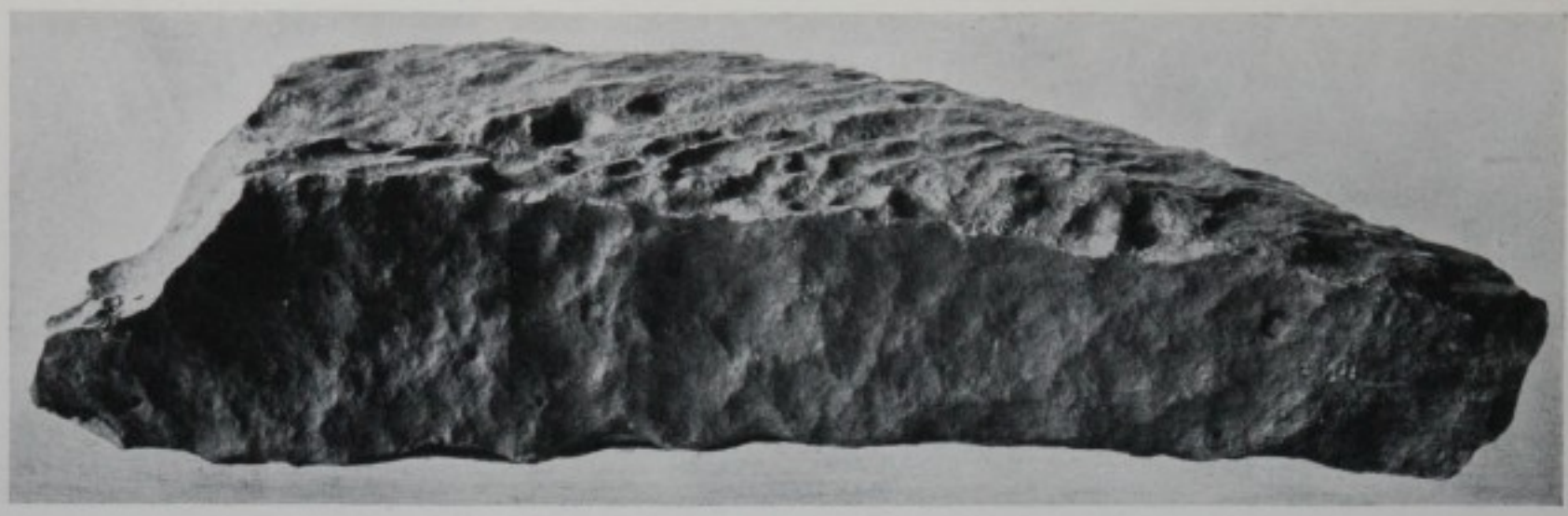
H. W. M. Olbers, 1758-1840, a famous German astronomer who joined in discussions of the problem of the origin of meteorites.

one of its younger members, Jean Baptiste Biot, who had been sent out to investigate a report of fallen stones.

From admitting the fall of meteorites to agreeing with Chladni as to their cosmic origin was, however, a very long step. Twenty years later the question was still undecided. Wasn't it more likely that meteorites form in our own atmosphere, in the manner of rain and hail, asked P. Egen, a German teacher

Because volcanoes are known to throw "bombs" and rocks to great heights, the fall of meteorites was often attributed to volcanoes. This volcano erupted on Lepari Island in 1888.





Many of the "fallen masses" that were being discussed and analyzed were first recovered by nonscientific people, in many parts of the world. This is the Guffey meteorite, found in the early 20th century by two cowboys in Park County, Colo. The composition of iron meteorites like this one, which is 88.7 per cent iron, 10.6 per cent nickel, and 0.54 per cent cobalt, was beginning to be known, but was not easily explained, in the late 1700's and early 1800's. The Guffey meteorite is three feet long and weighs 682 pounds. American Museum of Natural History photograph.

of mathematics and physics. What better proof of their earthly origin could there be than that virtually all of their constituent elements are found right here on earth?

But Chladni, by then a professor famous for his studies on sound, replied that the only conclusion was that nature in creating the universe had made use of fairly similar materials. Further, how could the atmosphere possibly carry the elements found in a meteorite?

But Egen had a theory, too: Consider the enormous quantities of solid matter that are daily volatilized in the processing of ore alone. These vapors rise to the higher regions of the atmosphere, where the electric fluid makes them combine to form solid compounds. In addition, the electric fluid gives them enough energy to account for their high velocity and for their sometimes nearly horizontal paths with respect to the earth. The electric fluid also ignites the sulphur which they contain and thus makes them luminous while they descend.

This "electric fluid" had at the time just been propounded as a force of nature to which various electrical phenomena could be attributed. It was made to account for all and sundry. But Egen got much support, and it was found that even the famous Edmund Halley had stated in 1719 that he then believed meteorites to be of terrestrial origin. Someone else tried to tie in meteorites with another "electric" phenomenon, the northern lights, and "proved" by means of statistics that there was a marked correlation between them.

The reader, secure in his present-day knowledge, may smile at the naivete of some of these early theories, and at the apparent blindness of the scientists of that time. He may know how in the 1830's the radiant origin of some meteor showers became recognized and how this gradually led to the acceptance of their extraterrestrial origin. But let him remember that, if our forefathers were blind, so surely are we, as we tap with ceaseless curiosity along the slowly retreating wall of the great unknown.

Student Observations of Delta Cephei — An Example

(Complete discussion by Peter van de Kamp on page 208)

AN ILLUSTRATION of the procedure is given from a series of observations made by Phoebe Burnett, Swarthmore '53, on 61 evenings from 1950 October 1 to 1951 January 11 (October 103). The observations range from A-B to D-E, and are plotted in Fig. 2, showing the first step in the reduction procedure. From this preliminary curve the order numbers and epochs of the apparent maxima and minima are computed, as listed at the left.

Maxima		Minima	
No.	Date	No.	Date
1	Oct. 4	1	Oct. 2
2	10	2	7
3	15	3	12
4	20	4	18
5	25	6	28
6	30	8	39
7	36	9	45
8	41	12	60
9	46	13	66
10	52	15	77
12	62	17	88
14	73	19	98
15	78	20	103
16	84		
17	89		
18	95		
19	100		

The second step is to take the differences for the most extreme epochs, as for the maxima: $19 - 1 = 18$, $100 - 4 = 96$; then for the next most extreme epochs, $18 - 2 = 16$, $95 - 10 = 85$; proceeding in this manner to pair off epochs of successively shorter intervals and to set up the following equations of condition ($\mathbf{nP} = \mathbf{I}$):

Maxima	Minima
$18\,P = 96$	$19\,P = 101$
$16\,P = 85$	$17\,P = 91$
$14\,P = 74$	$14\,P = 76$
$12\,P = 64$	$11\,P = 59$
$10\,P = 53$	$7\,P = 38$
$8\,P = 43$	$4\,P = 21$
$5\,P = 26$	
$2\,P = 11$	

The third step is to apply the normalizing or weighting factors by multiplying both sides of each equation by the respective value of **n**. The first maximum equation thus becomes $18 \times 18\,\mathbf{P} = 96 \times 18$, or $324\,\mathbf{P} = 1728$; the second maximum equation becomes $256\,\mathbf{P} = 1360$; and so on. These equations are then added, which produces the two normal equations:

Maxima: $1113\,\mathbf{P} = 5918$; $\mathbf{P} = 5.32$ days

Minima: $1032\,\mathbf{P} = 5529$; $\mathbf{P} = 5.36$ days

The average period of 5.34 days was used to plot the points in Fig. 3, and these were then averaged to obtain the seven normal points through which the final curve was drawn as closely as possible. The adopted period is not far from the well-established value of 5.3663 days.

The maximum brightness is somewhat brighter than B, the minimum somewhat fainter than D, representing a range of nearly half a magnitude. For comparison, Wesselink's photovisual light curve is given as Fig. 4. This curve is based on 2,448 exposures on 236 plates, taken on 159 nights in the interval 1932-1942. Wesselink's range in brightness is 0.85 magnitude; the smallness of Miss Burnett's magnitude range is probably due to color equation.

Amateur Astronomers

League Convention Field Trips and Program

THREE FIELD TRIPS have been planned for the coming Astronomical League convention to be held in Washington, D. C., over the Labor Day weekend, September 4-7.

On Friday evening, September 4th, there will be a tour through the U. S. Naval Observatory. Located on the observatory grounds are a 26-inch refractor and 40-inch reflector, as well as other instruments. If weather permits, there will be an opportunity to view the sky with one of the large telescopes. The delegates will also be taken for a tour of the buildings, including that housing the National Capital Astronomers' 5-inch Alvan Clark refractor.

The Naval Observatory is one of the few institutions in the world and the only one in the United States at which fundamental positions of the sun, moon, planets, and stars are continually determined. From some of the observations, time determinations are made, and upon others are based the tables and star catalogues used in preparing the annual navigational almanacs. Time signals sent by radio from various government stations are regulated by the Naval Observatory.

Georgetown University Observatory will be the site of the field trip on Saturday evening, where conventionites will be guests of the Rev. Francis J. Heyden, S.J., director of the observatory. After a buffet supper served on the grounds, there will be a trip through the observatory, one of the oldest in the United States, and observing, weather permitting. Amateurs will also have an opportunity to view the photographs taken at the observatory and on the various Georgetown eclipse expeditions.

On Sunday morning, September 6th, the convention will have a field trip to Anacostia, D.C., to see the radio astronomy equipment of the Naval Research Laboratory, which consists of several radio telescopes, the largest a solid metal parabolic reflector, 50 feet in diameter. This "dish" operates on a modified gun mount atop one of the buildings. Since a gun mount is essentially altazimuth, it is necessary by automatic controls to convert the motion to that of an equatorial mounting, so as to drive the big reflector properly. The convention committee must submit a list of all persons who are to be admitted to the Naval Research Laboratory, and it will therefore be necessary to register in advance in order to make this trip.

Chartered buses will provide transportation on the field trips. The round-trip fare for the Naval Observatory and Naval Research Laboratory trips is 75 cents each, and the trip to Georgetown Observatory is $2.25, including buffet supper and bus fare.

Persons who are interested in attending the convention and taking part in the field trips should send the registration fee ($1.00 until June 1st, after that $1.50) to Mrs. Ione Alston, 20 Plattsburg Court, N.W., Washington 16, D. C., who will then forward more detailed information about the convention, hotel reservations, and the field trips.

Under the chairmanship of Charles H. LeRoy, the program committee has drawn up the accompanying tentative convention program. Sessions for papers and the exhibit will be at the Carnegie Institution of Washington.

G. R. Wright, convention chairman

Friday, September 4, 1953	
9:00 a.m. to noon	Council meeting.
9:00 a.m. to 6:00 p.m.	Setting up exhibits.
3:00 to 6:00 p.m.	Registration.
6:00 to 7:30 p.m.	Past presidents' and officers' dinner.
7:30 to 10:00 p.m.	Field trip to U. S. Naval Observatory.
Saturday, September 5, 1953	
9:00 to 10:00 a.m.	Registration.
9:00 to 10:00 a.m.	Middle East regional meeting.
10:00 a.m. to noon	Business session. Reports. Announcements.
1:00 to 5:00 p.m.	Observing session: lunar, variable star, planet, and aurora sections.
6:00 to 10:00 p.m.	Field trip to Georgetown Observatory. Buffet supper on lawn. Observing.
Sunday, September 6, 1953	
9:00 a.m. to noon	Field trip to Naval Research Laboratory.
1:00 to 3:00 p.m.	Business session. Elections.
3:00 to 4:00 p.m.	Junior session.
4:00 to 5:30 p.m.	Radio astronomy session.
7:00 to 10:00 p.m.	High-altitude rockets and related subjects.
Monday, September 7, 1953 (Labor Day)	
9:00 to 11:30 a.m.	Instruments session. The latest in amateur and professional equipment.
11:30 a.m. to 12:30 p.m.	"Operation Eclipse," planning the 1954 total eclipse expedition and convention.
12:30 p.m.	Adjournment.

NORTH CENTRAL CONVENTION

The North Central region of the Astronomical League will hold its annual convention in the Quad-city area, on Friday and Saturday, July 17-18. The Popular Astronomy Club of Moline, Ill., is the host society. Joseph A. Anderer is the regional chairman.

Registration opens at 2 o'clock Friday afternoon, followed by a session in the library building of Augustana College, in Rock Island, devoted to papers and society reports. A picnic supper will be held at Carl H. Gamble's Sky Ridge Observatory in Moline, followed by observing with the 5½-inch Zeiss refractor and portable instruments. There will be a lecture Saturday morning, and a business meeting, with convention adjournment shortly after noontime.

Augustana College is providing dormitory sleeping quarters, including breakfast, at $2.00 per person. Overnight reservations and pre-convention registration ($1.00) may be sent to H. John Schieck, 3303 Coaltown Rd., Moline, Ill.

CHICAGO JUNIOR GROUP

The Burnham Astronomical Society of Chicago now has a junior section, consisting at present of 23 members, aged nine through 15. The group has existed independently for over a year and a half, under the guidance of Albert V. Shatzel, assistant director of the Adler Planetarium. Biweekly meetings are held, at which Mr. Shatzel lectures, and it is planned for members of the adult organization to give talks on their specialties, thereby providing the juniors a well-rounded program.

The telescope making facilities of the planetarium have been used for mirrors from 4½ to 10 inches, many now mounted in completed instruments. One member is making variable star observations, and efforts will be made to widen the interest in observing among the juniors.

JOSEPH A. ANDERER
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THIS MONTH'S MEETINGS

Dallas, Tex.: Texas Astronomical Society. June 15, 8 p.m., field meet, Dr. Arch J. McNeill's "Log Cabin," 7814 Forney Rd., public invited.

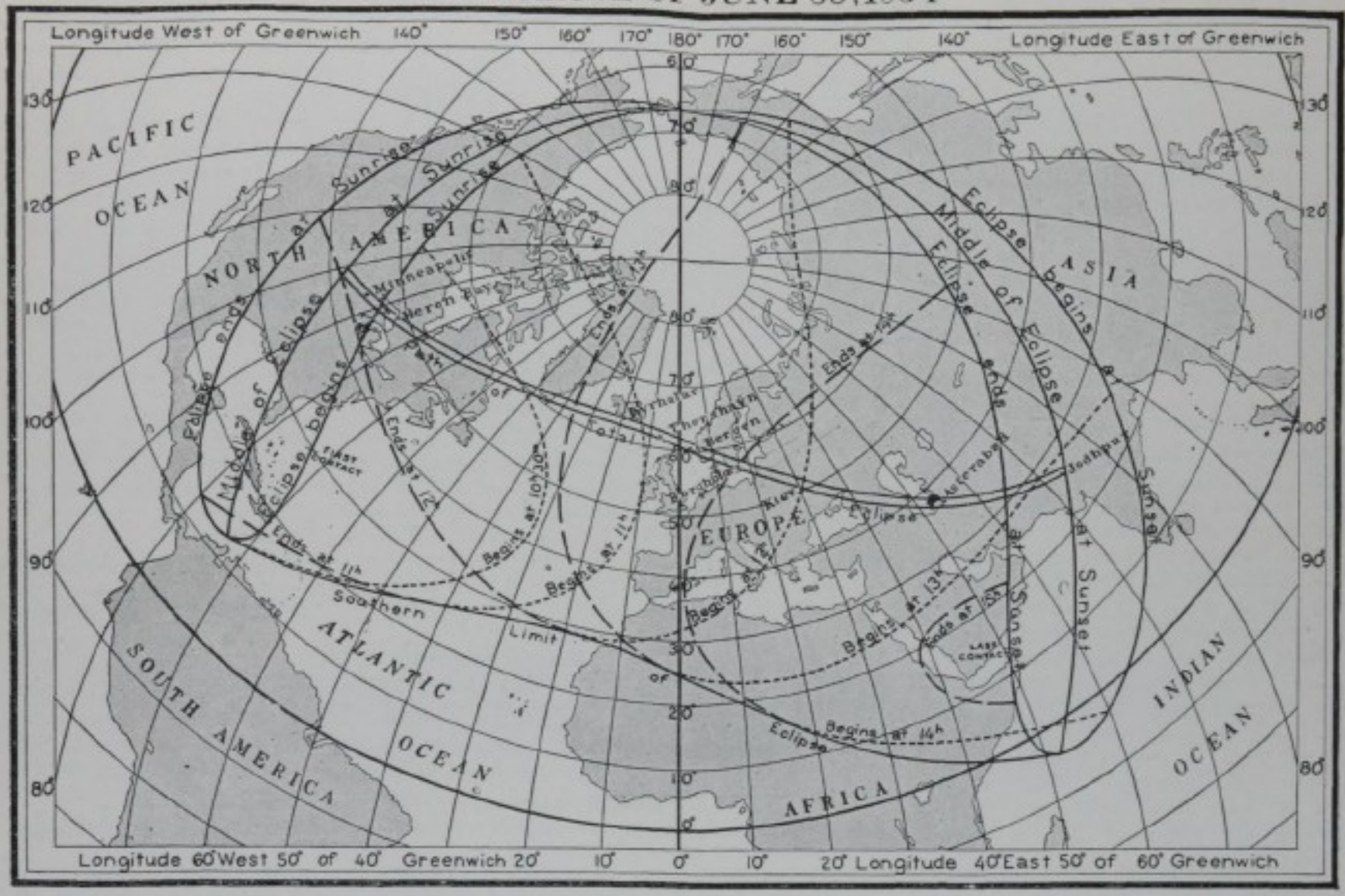
Geneva, Ill.: Fox Valley Astronomical Society. June 14, annual picnic, Aurora College, Aurora, Ill. 4:30 p.m., Wagner Schlesinger, Adler Planetarium, "Eclipsing Binaries"; 6:30, picnic supper; 8:30, observations.

Indianapolis, Ind.: Indiana Astronomical Society, 2:15 p.m., Link Observatory. June 7, Dr. Goethe Link, "The Link Observatory."

Kalamazoo, Mich.: Kalamazoo Amateur Astronomical Association. June 13, Wolf Lake. Edgar Pashby, "Lenses."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Building auditorium. June 6, astronomical films on "Viewing the Universe."

TOTAL ECLIPSE OF JUNE 30, 1954



This map, reproduced from the "American Ephemeris and Nautical Almanac," shows the vast region from which the partial phases of the total eclipse of next June will be seen, and the path of the total phase. Universal time is used.

Next Year's Favorable Total Eclipse

By Paul W. Stevens

PREPARATIONS are now being made for observations of the next total eclipse of the sun. It will take place on June 30, 1954, and is of great interest to Americans and Canadians because the path of the total phase begins in the northern part of the central United States and continues in a northeasterly direction across Lake Superior and much of Canada. Readers were introduced to this eclipse in a note last August.

The eclipse should be widely observed, inasmuch as it passes over more land than water. Although much of the area is sparsely inhabited, the path of totality crosses near large centers of population, particularly in the United States, Scandinavia, and the Soviet Union. European and Russian astronomers will also undoubtedly make elaborate plans for an eclipse that may be observed with a minimum of travel time.

The circumstances of this eclipse are in many ways similar to those of the one on July 9, 1945. It is suggested that readers refer to the numerous articles in *Sky and Telescope* of that year, including both those which gave advance information and those which recounted actual eclipse experiences. There was something from January through October.

The 1945 eclipse began at sunrise in Idaho, the shadow crossing the Montana-Saskatchewan border near Opheim, Mont., thence proceeding directly across Lake Winnipeg and out over Hudson Bay midway between Fort Severn and York Factory. Next year's shadow will begin about 800 miles farther east, in Holt County, Neb., pass across Minneapolis and St. Paul, out over Lake Superior and Rupert House at the foot of James Bay. This region is closer to large centers of population and even more accessible than was the same portion of the 1945 eclipse path.

Because it occurs on a Wednesday morning shortly after the regular school year is over, the eclipse will be very conveniently timed for most people in the United States who wish to travel to the path of totality and return during a one-week vacation. For travelers by automobile, the Keweenaw Peninsula in Michigan, on the south shore of Lake Superior, is recommended. There the entire eclipse will take place after sunrise, and the duration of totality on the central line will be 82 seconds, with the sun and moon at an altitude of 10 degrees. The *maximum* duration of totality in 1945 was only 75 seconds, in Greenland; thus, this eclipse is far more favorable to observers in North America. In 1945, the sun was at an altitude of nearly nine degrees at Opheim, Mont.; in this respect, the eclipses are similar.

A total eclipse of the sun can be most favorably observed near the meridian at which mid-eclipse occurs at noon, in this case the Greenwich meridian. It is in that vicinity that the sun has its highest altitude and the duration of totality is a maximum (155 seconds, at a point west of southern Norway). Except for modifications due to climate and topography, such conditions are best for scientific observations.

When expeditions travel great distances to observe an eclipse, it is desirable to choose a site within the middle third

of the length of the central line. In this case the middle third lies mostly over water, although crossing Greenland and other important islands of the North Atlantic. Nevertheless, most of the observing will probably be done in the remaining two thirds of the shadow path, both in North America and in Europe and Asia. This will be particularly true for the geodetic measurements, as it is advantageous to station parties at points well distributed along the entire path, so measurements can be taken to tie together the fundamental triangulation surveys of widely separated geographical entities. The 1954 eclipse is particularly favorable to work of this kind and will tie together parts of three continents.

In the United States and Canada, it is hoped that the geographical distribution of amateur observers will be widespread. Of particular value in establishing the exact limits of totality are observations by those who must remain at home and will be located near the edges of the path.

As a sunrise phenomenon, the eclipse will be of unusual interest in our northern Middle West, for a total eclipse near sunrise or sunset merits considerable attention as a spectacle of grandeur. The rosy color of the sky is of great beauty when the eclipse is seen near the horizon, the varieties being as endless as those of a normal sunset. The rising of a thin crescent sun in a darkening sky holds a thrill for the observer.

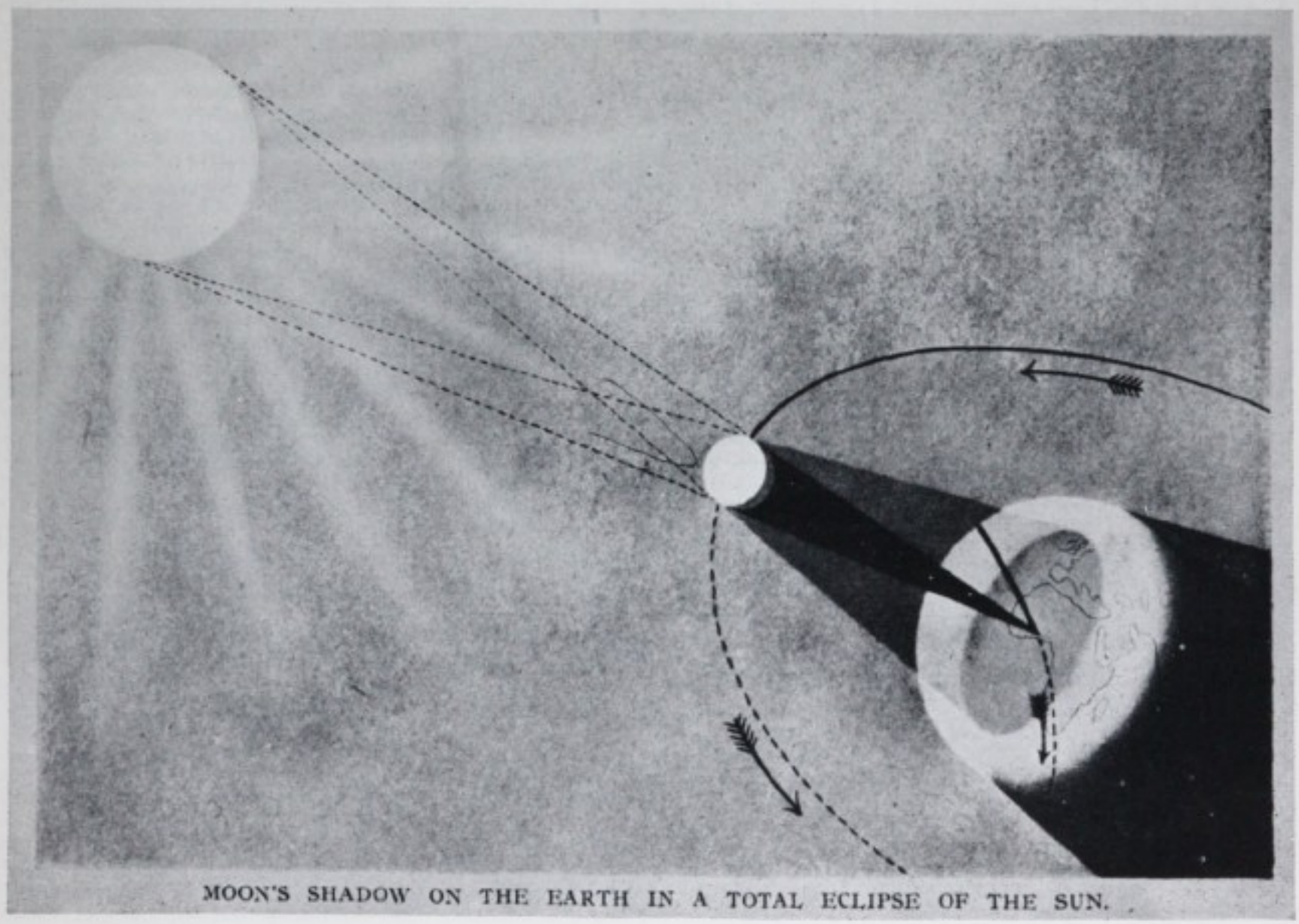
Little has been written of the view seen where totality occurs below the horizon, and it is hoped that in 1954 many such observations will be made. The changing color and brightness of the dawn follow an unexpected pattern, and the sweep of the moon's shadow across the sky is a novelty. The zodiacal light appears of unusual brightness and extent and should be of special interest where moon and sun are five to 10 degrees below the horizon. There will be fine opportunities to see this phase of the phenomenon in the Rocky Mountains, where conditions of topographic altitude and atmospheric clarity are favorable.

One of the interesting sidelights of a total solar eclipse is the appearance of stars and planets during totality. In June, 1954, the stellar background will include the famous bright stars of northern winters. A most rare circumstance will be the invisibility of Jupiter behind the solar disk. The giant planet will be obscured by the sun throughout the entire period of the eclipse for an observer anywhere in the world. This situation was discussed by the writer in *Sky and Telescope* for May, 1947.

Mercury will be a slender crescent (telescopically) close to the sun, rising for observers near the American shore of Lake Superior. Venus will make its appearance during totality in eastern Canada, while Saturn will not rise until the moon's shadow is somewhere in Europe. Mars will be close to opposition to the sun, and will be observed to disappear in the west after dawn has broken.

The writer has studied the eclipse supplement to the 1954 *American Ephemeris* describing this eclipse and mentioned in the note of August, 1952. Using data in the supplement and in the *Ephemeris* itself, computations have been made revealing circumstances of the eclipse that are of general interest. This is in addition to the information that can be found directly by reference to the tables and maps printed in one or the other of these two sources. In subsequent issues of this magazine, it is planned to reproduce some of the special maps in the supplement and to explain their important features.

NOTE: *Sky and Telescope* will act as a clearinghouse for its readers on plans and problems concerning this eclipse. Correspondence is solicited from amateur and professional astronomers and groups interested in observing the eclipse, who may wish to announce their observing plans or request information from our readers. It will be appreciated if the directors of observatories everywhere will communicate their preliminary plans for observing the eclipse as soon as these become definite enough to merit publication. Every effort will be made to give prompt publication to pertinent eclipse articles, notes, announcements, requests, and eclipse information of all kinds. —ED.



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BOOKS AND THE SKY

OUR NEIGHBOUR WORLDS

V. A. Firsoff. Hutchinson's Scientific and Technical Publications, Stratford Pl., London W.1, England, 1952. 336 pages. 25s.

PRIMARILY of interest to the armchair astronaut, this entertaining book is also of value to all who have astronomy as an avocation. Mr. Firsoff is obviously well equipped for his topic, and he handles it with imagination and zest. In fact, **Our Neighbour Worlds** might be characterized as the most optimistic and imaginative treatment of the solar system possible without doing serious damage to established observational facts.

In defending habitability of the planets, the possibility of intelligent life on some of them, and our prospects of travel to them, it is surprising how far a writer like Mr. Firsoff can go and still remain in the domain of the possible, if not always in that of the probable. The major portion of the book is devoted to an account of present-day knowledge of conditions on the earth's fellow planets, but this is no ordinary treatment, for the author makes generous allowances in the interpretations of physical observations. In introducing his long and detailed chapter on Mars, he states:

"Many astronomers have taken refuge in impartially reporting the opinions of others. Yet, laudable as the pursuit of impartiality may be in itself, it is seldom very convincing, is often cramping and occasionally degenerates into a merely negative attitude of pooh-poohing every finding, every suggestion, without offering anything constructive in return."

There is no hint of negative attitude anywhere in this book! In putting each planet's best foot forward, Mr. Firsoff occasionally places a great strain on credulity, as when, in discussing Mercury, he states, ". . . the rift valleys of Mercury offer a possible foothold to life, . . ." and then, "For all we know Mercury could be inhabited by an intelligent race which has succeeded in harnessing the great potential source of energy in the intense solar radiation. . . ." He admits, "This is speculation verging on fiction, but 'life is stranger than fiction' and we must beware of yielding to the present vogue of peopling the skies with desiccated and uninhabitable editions of Arizona."

He has no intention of so doing in appraising Venus as a possible abode of life. The observational facts are, of course, that spectroscopic analysis reveals no water vapor nor free oxygen above the cloud layer of Venus, but a great deal of carbon dioxide. These facts have led conservative astronomers to hold forth little hope for intelligent life on Venus. Not so our author! He feels that there may be copious supplies of oxygen and water below the planet's clouds, neglecting the point that if carbon dioxide is observed at heights above the clouds, so should be the lighter oxygen and water. He feels that organic processes may be available, such as those found in the anaerobic bacteria on the earth which extract oxygen from carbon dioxide and can produce, in this manner, water from hydrogen-containing substances.

And so it goes. With the skill of a debater picking loopholes in his conservative opponents' arguments, and with very liberal allowance for possible errors of observation and their interpretation, he concludes, with respect to Venus, for instance, "What will explorers find on Venus? . . . I have my own vision of a Venusian scene. . . . A pale green sky with a very high ceiling of ribbed yellow clouds, through which a large golden Sun shimmers dimly. Below is the sea of an unbelievably brilliant blue and islands covered with exuberant, multi-colored vegetation. Tall red mountains are capped with snow."

The two earlier sections of the book, those describing the solar system, the astronomer's means of attack on planetary problems, and the consideration of the principles and state of the art of rocketry, do not offer the author the scope for play of imagination that the larger section just described does.

The first section offers a creditable review of the facts of our solar system and a mature and encompassing view of the battery of astronomical instruments concerned in man's observational attack on the planets. It includes, however, a somewhat out-of-place account of the author's theory of the origin of the solar system. This utilizes a supernova explosion to carry material to planetary distances. As with many earlier theories of origins, nothing is said of how the planets obtained their very large share of angular momentum, or in short, what set them in motion around the sun. This "quantity of motion" could not have come from the radial ejection of material from the sun. Angular momentum is a formidable stumbling block for makers of theories that call for the birth of planetary material from the body of the sun. The author appears uninformed of the Kuiper-von Weizsaecker approaches to the problem.

Four centrally located chapters in **Our Neighbour Worlds** deal with space flight and rockets. Here our author has many more facts to deal with — the facts of dynamics and mechanics. Here we read much of such things as mass ratio, free ascent, step-rockets, ordinary and atomic fuels, electromagnetic boosters, space stations and space fuel dumps, sun mirrors, braking ellipses, Hohmann orbits, space suits and space hazards. The Hohmann orbit, incidentally, is one which takes minimum energy but often maximum time — thus, 146 days to Venus and 259 days to Mars.

Of space hazards, meteors are not considered among the most formidable; meteor puncture could be expected only once every three weeks and the resulting hole "could be mended with an ordinary bicycle repair outfit."

With regard to sun mirrors and space stations, the author brings up, in passing, the old story of the "sun-gun." This was to be a huge sodium foil concave mirror some 30 square miles or more in area. It was to be "anchored" in an orbit and was to wreak havoc on civilizations below. What appears to have been overlooked by enthusiastic supporters of this fanciful

weapon is that to be "anchored" the sun-gun must be 22,300 miles above the earth's surface. The mirror must, therefore, have that long a focal length, and since image size depends only upon focal length, the sun's image upon the earth's surface would be some 200 miles in diameter! With so huge an image, the light gathered by this solar mirror would be spread exceedingly thin. The mirror itself would appear to the observer below as a bright point of light less than a minute of arc across.

The critical reader will find many spots of loose thinking, of exposition simplified to the point of ambiguity, and few of downright error. Nonetheless, this book, taken as a whole, can be recommended for the armchair amateur. The illustrations are good, the paper and printing are excellent, and especially valuable is the list of references at the end of each chapter. These are indeed redeeming features. Another is a short mathematical appendix.

J. ALLEN HYNEK
Ohio State University

ADVANCES IN GEOPHYSICS, I

H. E. Landsberg, editor. Academic Press, Inc., New York, 1952. 362 pages. $7.80.

THERE IS no real dividing line between the earth sciences and astronomy. Their close historical association is evident upon looking into any astronomical periodical from early in the last century, where it will be found that as many papers are devoted to geodesy, terrestrial magnetism, and meteorology as to astronomy itself. Today the study of the upper atmosphere is pursued equally by astronomers and geophysicists. From the astronomical viewpoint, geophysics might be defined as a special branch of astrophysics which treats the most accessible of all astronomical bodies, the earth.

Thus, there is a real need for a concise review of current developments in the geophysical sciences, presented in a form suited to the needs of a reader whose bent is primarily astronomical. This need is well met by the new series, **Advances in Geophysics,** of which the first volume has just appeared under the editorship of H. E. Landsberg, director of the Geophysics Research Directorate, Air Force Cambridge Research Center.

Of the eight contributions in this volume, that of most astronomical interest is "Exploration of the Upper Atmosphere by Meteoritic Methods," by F. L. Whipple, of Harvard Observatory. This is an excellent 50-page summary of present knowledge about meteors, clearly enough written to be easily read by an advanced amateur. One point brought out by Whipple should be mentioned. While visual observations of meteors have been driven into obsolescence by the more powerful photographic and radar techniques, there is an important exception. This is observation of the drift of long-enduring meteor trains, from which valuable information can be gained on winds in the upper atmosphere.

The remainder of the book is more likely to attract the professional rather than the general reader. The first two chapters will particularly interest astronomers. All who are concerned with the measurement and reduction of photographs on a large scale find a serious bottleneck in the recording and processing of data. J. C. Bellamy gives a useful and thought-evoking analysis of the mechanization of analogous procedures in geophysics. Arnold Court describes new statistical techniques in geophysics which could easily be adapted to problems in astronomy.

The value of **Advances in Geophysics** is enhanced by good indices and full bibliographies. An attractive feature is the listing at the end of each chapter of the mathematical notation used.

JOSEPH ASHBROOK
Yale University Observatory

NEW BOOKS RECEIVED

THE COMETS AND THEIR ORIGIN, *R. A. Lyttleton,* 1953, *Cambridge University Press.* 173 pages. $5.00.

A discussion of the properties of comets, dynamical and physical, is followed by the presentation and development of the author's theory for their origin and formation, in brief, a process "of the accretion of interstellar dust through the gravitational action of the sun during passages through galactic dust clouds." The formation of comet tails is then considered.

PHOTOGRAPHY AND THE AMATEUR ASTRONOMER, *Gerald Merton,* 1953, *British Astronomical Association,* 303 Bath Rd., Hounslow West, Middlesex, England. 24 pages. 2s.

Issued as BAA Reprint No. 1, this booklet contains the address of the retiring president first printed in the BAA *Journal* of December, 1952. (See In the Current Journals, *Sky and Telescope,* March, 1953, page 128.) The author gives a historical sketch, discusses emulsions, photogenic response, reciprocity failure, limiting magnitudes, complicating factors, diameters of star images and magnitudes, cameras. A short section on photographic work in the BAA observing sections and a full bibliography conclude the booklet, which is illustrated with halftones and diagrams.

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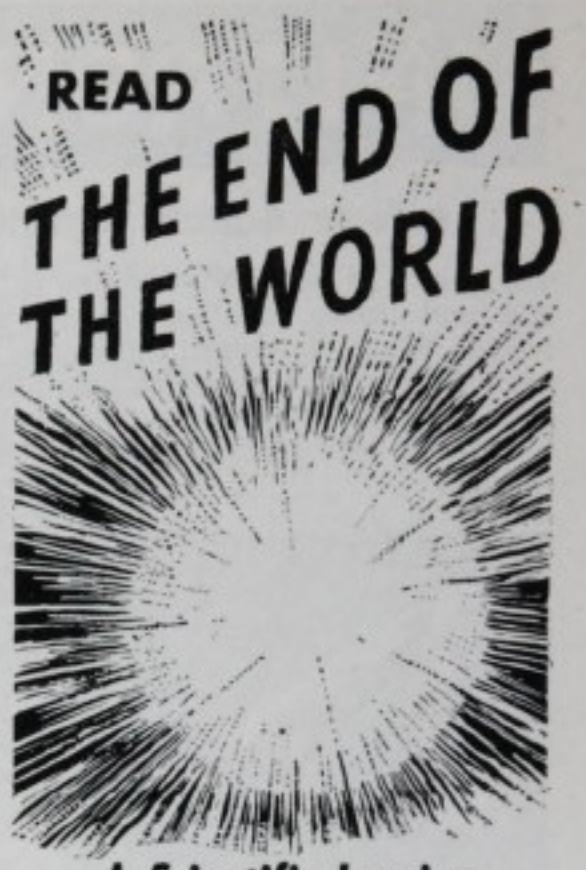

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GLEANINGS FOR ATM's

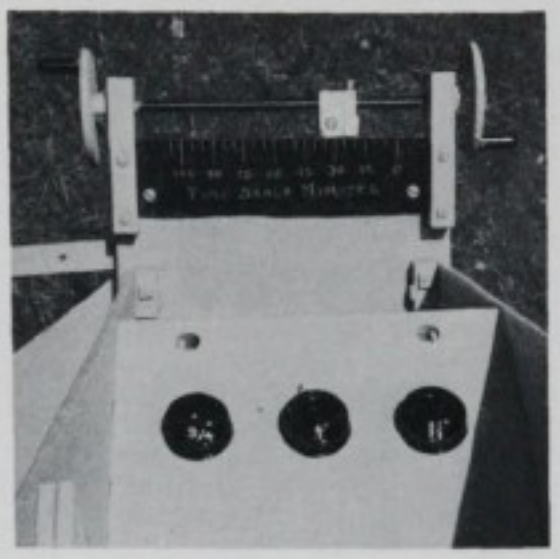
EDITED BY EARLE B. BROWN

Inexpensive Portable Planetary Telescopes

THIS ARTICLE is written for the amateur astronomer who wants to build a telescope at minimum cost. The optical parts, which consist of a 3-, 4-, 5-, or 6-inch diameter mirror, ground, polished, and aluminized, ready to use, with an aluminized diagonal and two eyepiece lenses, can be purchased for a reasonable sum.

The instruments can be made at home with simple hand tools by the average home worker. The mounting is light and easily portable; it can be taken indoors when not in use, or can be carried in a car on trips to the country. Setting scales are provided for right ascension and declination, so that Venus or Mercury can be located in the daytime, when they are best seen, and comets or other objects invisible to the naked eye at night can also be found. To keep the telescope accurately trained on an object, a slow-motion manual-drive tangent screw is used. A smooth slow-motion drive is especially needed for high powers, when the object appears to slide rapidly out of the field of view. For planetary work the primary mirror should have a focal length at least 10 times its diameter. A long focal length mirror produces a larger image, so that low-power eyepieces can be used for all general work.

High-power telescopes magnify any motion or vibration, and with a flimsy mounting stars may dance around in the field, causing eye strain and making it difficult or impossible to see fine detail. To eliminate this trouble the mountings have a distance between polar-axis bearings of 10" for the smallest reflector and 22" for the largest.



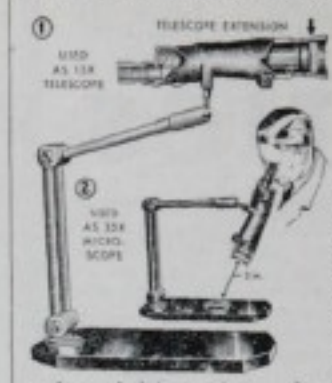
A view of the right-ascension tangent screw, time scale, and storage place for eyepieces, looking down the length of the carriage that forms the polar-axis support.

In declination the telescope covers a section of the heavens from the southern horizon to the zenith. At 40° north latitude the telescope can be set in declination from −50° to +40°. This section provides for all the planets, and most of the other popular objects for small telescopes.

A tube to mount the optics is required. Duro-board cores, used by paper mills, are about 3/10" thick and make very rigid tubes. These are preferable to metal tubes,

The author here demonstrates the slow motion in right ascension of the 4-inch telescope, which is one of the battery of instruments pictured on the front cover, ranging in size from 3-inch to 6-inch, all of the same fundamental design.

UNUSUAL OPTICAL BARGAINS



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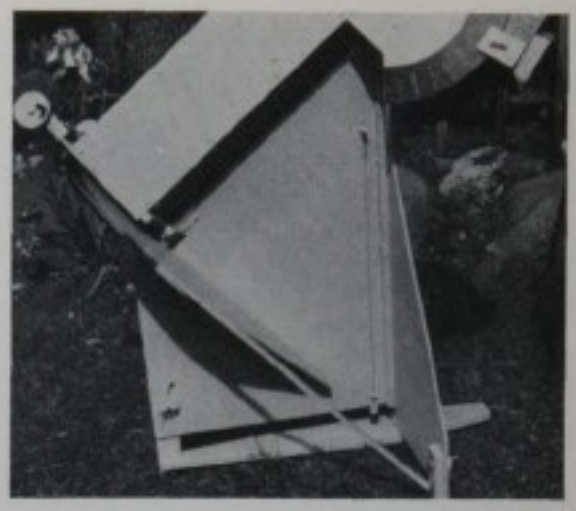
which conduct disturbing heat waves along their inner surface, causing distortion of the image. Any material which is an electrical insulator is also an insulator of heat waves, so that cardboard, fiber, wood, or bakelite tubes can be used to advantage. If a metal tube is used, be sure to insulate the inside surface with cork or other suitable material; otherwise the telescope may have to be left outdoors a half hour or more before it settles down, and on certain nights when the temperature is continually changing, it may never completely settle down. It is the writer's experience that aluminum, which is a very good conductor, is about the worst metal to use.

For neatness and precision in mounting the optical parts, the front end of the duroboard tube should be squared up using a fine-tooth hack saw and trimming any fuzzy edges with a knife or razor blade. Before cutting, draw a pencil line around the tube by using a piece of stiff unwrinkled paper wrapped around the tube to act as a guide for the pencil. The paper should be at least 12" wide and long enough to go completely around the tube so that the ends can be lined up. The marking edge of the paper must be trimmed on a straight line, the exact size and shape of the paper being unimportant. Where the paper strip overlaps, a mark should be made, the paper stretched flat, and the distance around the tube accurately divided into four equal parts. One inch down from the end of the tube draw a second line and mark the tube opposite the four marks just made on the paper. This will locate the 3/16" holes for mounting the spider. On a line perpendicular to the front end of the tube and 3" below one of the holes for the spider, make a mark for the location of the eyepiece holder. A little time and patience will enable the worker to cut a neat hole 1⅜" in diameter around this point.

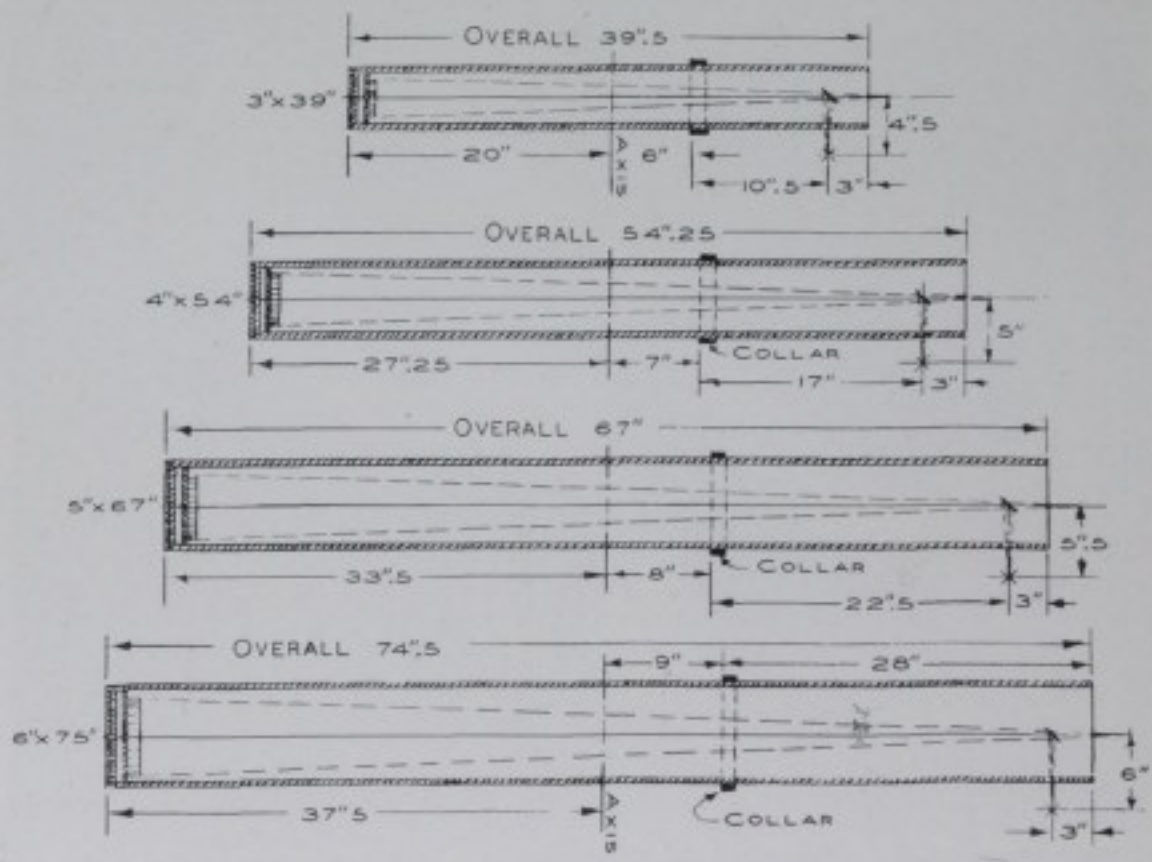
The collar is made from an old piece



Compare this view of the mounting and the plumb line used for leveling with the diagram on the opposite page.

of ¼" thick leather belting trimmed to a width of 1". This collar is used to keep the telescope tube from sliding down in the cradle. Drill holes for 3/16" by 5/8" round-head stove bolts, the first hole being 3/8" from the end of the belt and the other holes evenly spaced around the tube approximately 3" apart.

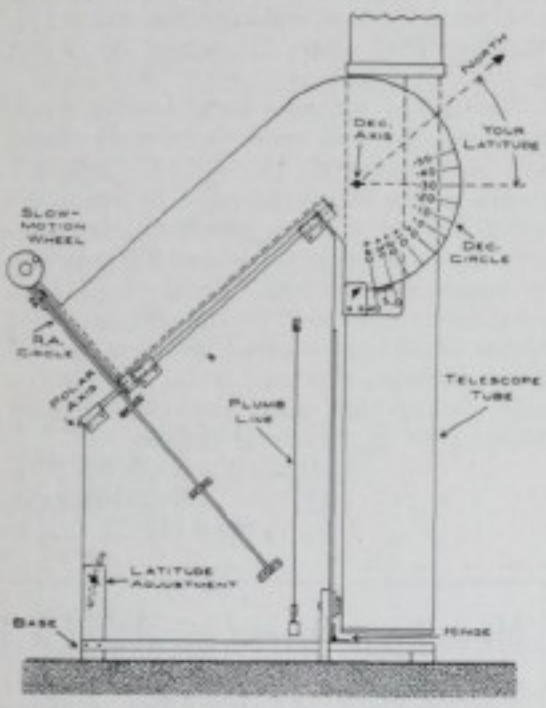
Paint the inside surface of the tube with one coat of flat black paint, and the outside with two coats of light gray enamel. All interior parts of the optical system should be painted with the flat black, being sure not to get any on the mirror or diagonal. Avoid touching the flat black as greasy fingers will spoil the dead black surface, causing reflections. (To strengthen the tube, before applying any paint give the cardboard one or more coats of varnish or shellac. This will act as sizing, and the paint will not be so readily absorbed and will spread on and dry more evenly. The more ambitious amateur will find that wooden rings turned to fit the top and bottom ends of the tube will also help strengthen the cardboard and add trim to the finished tube.)



This diagram, showing the location of the optical parts inside each tube, illustrates the manner of scaling the dimensions from the smallest up to the largest.

The telescope rests in a cradle, stopping against the leather collar, and is tied in place by a piece of lightweight sash cord. Be sure to make the cradle wide enough so that the telescope will fit freely between the side members. The bottom and sides are made of ¼" masonite, bolted to ⅝" by 1¼" wood strips at the inside corners with 3/16" stove bolts. The declination-axis pivots are two ⅜" fine-threaded hexagon-head cap screws, with a tight fit in the cradle and a free bearing fit in the carriage. The cradle carries a declination scale index graduated in degrees from 0 to 10, together with a 2" by 3" masonite clamp plate. A piece of felt under the clamp plate will prevent scratching the carriage graduations.

The carriage supporting the cradle has two side wings graduated every 10° of declination. The east and west wings carry identical graduations which can be



A diagram of the various parts of the mounting designed by Mr. Lawrence.

easily read for all positions of the telescope. The wings, bottom, and back of the carriage are all made from ¼" masonite, the inside joints bolted together with ⅝" square wood strips using 3/16" stove bolts. The width and height of the back plates are 8 x 8½, 8½ x 9½, 9 x 10½, and 9½ x 11½ inches for the four sizes of telescopes. The bottom carries two ¾" hardwood polar-axis bearings. The polar axis is made from ⅜" drill rod or cold rolled steel, held in place with sheet-metal straps. Note that the polar axis is stationary and the carriage bearings turn with the instrument in right ascension.

The pedestal has a central vertical plate with the polar axis mounted on its upper edge, a pear-shaped hole plate, and a front vertical plate for cross bracing, all made from ¼" masonite. These three members are fastened together with 3/16" stove bolts. The hole plate is used for setting and clamping the right-ascension arm, while the front vertical plate is hinged at the bottom edge to the base plate so that the mount can be leveled. This vertical plate is also slotted for two east-west adjustable legs used for cross-leveling. A plumb line is mounted on the side of the central vertical plate with two steel brackets to indicate a true vertical adjustment of the mount, in both vertical planes.

The tangent screw provides a smooth slow-motion drive for the telescope in right ascension, one revolution of the hand wheel being approximately one minute of time. The lead screw is made from ⅜" diameter, 16 threads per inch, standard threaded rod, which can be purchased from any large hardware store. It has a 3" masonite hand wheel on each end, with a hand crank made from any suitable radio knob. The hand wheels are clamped in place between two hexagon nuts which are also adjusted to remove any end play from the lead screw. The screw rotates on ball bearings and carries a traveling swivel nut with an index line to read against the time scale. The swivel nut is the most difficult part to make. It should be reamed for a sliding fit on the ⅜" by 6" steel rod, and carefully tapped to fit the lead screw, to work freely with a minimum of lost motion. A 2" masonite arm is held by a clamp using a 5/16" carriage bolt and wing nut. The arm provides a coarse setting for right ascension, and stops against a pin set in the hole plate, the holes being spaced one hour apart.

A star and planet finder, illustrated, has dials made from white-faced cardboard or bristol board with a maximum diameter of 12". The day-of-month scale is mounted to a backing of ¼" masonite and remains fixed. The outer dial is 12" in diameter and shows the months and the hours of right ascension from 0 to 24. The second dial is 10½" in diameter and is graduated with a scale showing minutes of right ascension and minutes of clock time from

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0 to 60. The third dial is 9½" in diameter and has hours of clock time, a.m. and p.m., together with an arbitrary telescope time scale from 0 to 120 minutes. The fourth or inner dial remains fixed, after setting for your east-west position. The dial has half of the circumference divided into 12 parts representing the "hole number" settings on the telescope mount. A piece of ¼" steel rod makes a good pivot for locating the dials centrally.

Scale and dial graduations can be laid out by a very simple method. Cut out a cardboard circle 29-1/16" in diameter from a packing box or other suitable material, and stretch a steel tape counterclockwise around the outer edge. (The circumference should be exactly 91¼".) Lay off months of the year using the following scale: ¼" Jan. 1; 8" Feb. 1; 15" Mar. 1; 22¾" Apr. 1; 30¼" May 1; 38" June 1; 45½" July 1; 53¼" Aug. 1; 61" Sept. 1; 68½" Oct. 1; 76¼" Nov. 1; and 83¾" Dec. 1. Starting at January 1, lay off 31 days using ¼" for each day, and number the days 0, 5, 10, 15, 20, 25, 30 in clockwise direction from February 1 to January 1. This protractor is used to lay out the days and months on the star and planet finder.

A second protractor 28⅝" in diameter (90" circumference) will be required to lay out the other dials and scales. Stretch the steel tape around the outer edge in a counterclockwise direction and mark off 24 hours. Note that one hour equals 3¾", 2 equals 7½", 3 equals 11¼", 4 equals 15". This protractor is used to lay out the right-ascension hour dials, the a.m.-p.m. clock time dial, and the telescope hole numbers. Next we mark off 120 minutes, in 5-minute steps (5 minutes equals 5/16") and lay out the telescope time scale. This minute protractor is also used to lay out the minutes of right ascension, minutes of clock time, and the finder telescope time scales. On the back side of the 28⅝" disk lay off 10 10-degree steps at 2½" intervals, and use this protractor to lay out the carriage declination scales. The declination index has 10 1-degree divisions; each degree on the circumference equals ¼". The index should be laid out first, and the carriage 10-degree scale graduations and legends should be marked on the brown surface of the tempered masonite using a good grade white crayon pencil (Eberhard Faber's extra thin Colorbrite White #2111 is excellent for the purpose). Keep the point well sharpened in order to produce clean-cut lines. India ink will also make a good marking substance.

The setting of the star and planet finder is accomplished like the setting of a planisphere. First the day of the month is set, then the right ascension of the star or planet, then the clock time. All of these settings are then locked to the telescope mounting by means of one of the hourly telescope holes, and the slow-motion control takes over for as long as two hours. This device permits changing from one object to another with a minimum loss of time and telescope position. Alignment on the north pole of the sky may be only approximate, or may be accomplished as described in various books on observing and on telescope making (see page 162, **Making Your Own Telescope,** by Allyn J. Thompson).

Because of the long focal lengths used, eyepieces do not have to be very short and high powered. A 1½", 1", and ¾" should prove satisfactory for generally all work. These can be purchased in war-surplus catalogues, or separate lenses can be bought and mounted to make one's own eyepieces. For best results the eyepiece lenses should be of equal focal length and plano-convex, mounted with the convex sides facing each other and separated by about 7/10 of the focal length.

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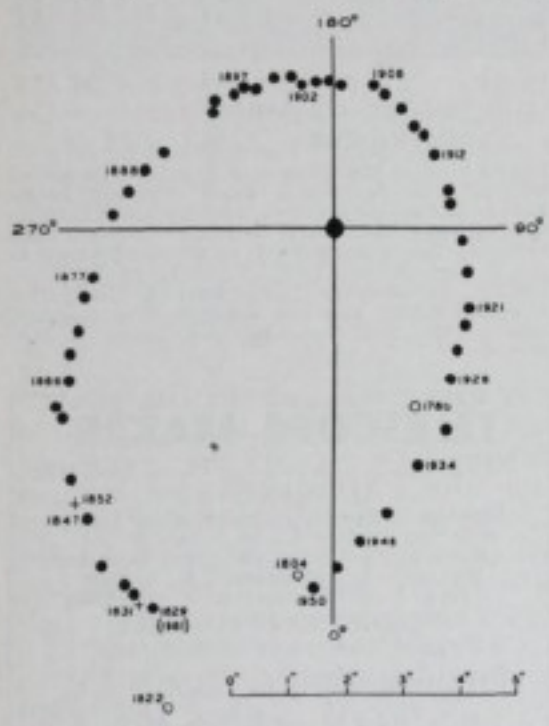
OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

WHEN Admiral Smyth entered Xi Bootis on the pages of his famous **Celestial Cycle** (1844), there was much doubt about the true binary nature of the system. The three early observations (shown on the diagram as open circles), because of the error of the 1822 observation, suggested that the companion was moving in a straight line. Then the 1829 position indicated a very elongated ellipse. So the good admiral watched this pair with attention (his first and last observations are plotted here as crosses), and the



The orbit of the visual binary star, Xi Bootis, from 1780 to the present. The 1780 and 1804 observations were by William Herschel.

accuracy of his work may be estimated from the way his plots fall on the curve. By the time he published his **Speculum Hartwellianium** (1860), he rejoiced that the binary nature of Xi Bootis was now beyond doubt. In another place he exclaims, "The physical connection of the components may therefore be deemed 'fully proven,' and that fact alone is a gratification to the contemplative mind."

The original William Herschel observation of 1780 is remarkably accurate when we consider the very amateurish nature of his instruments. He had no clock drive, no filar micrometer, not even an equatorial mounting — he used an altazimuth. Yet his position, checked against recent orbits, turns out to be only half a second of arc off in distance, and five degrees wrong in position angle. Using his position, the period comes out 152 years compared to the now accepted value of 151 years.

It was not until well into this century that the period was ascertained. Burnham's catalogue, with an orbit plot to 1905, remarks that it was still impossible to determine the period, and he gives references for orbits from 117 to 172 years, by various workers. Burnham, himself, thought the best observations indicated a period in the neighborhood of 175 years. When the Aitken catalogue came out with measures to 1926, the true period obviously touched close to 150 years, the matter was settled, and the old observation of Herschel was justified.

Measures after 1926 on the diagram are from the card catalogue of Lick Observatory through the courtesy of Dr. H. M. Jeffers.

Xi Bootis is one of the few bright binaries that revolves fast enough so that amateur records will indicate changes over a decade or so. It lies at $14^h\ 49^m.1$, $+19°\ 18'$ (1950); the components are of magnitude 4.7 and 6.6, spectra (by Mount Wilson) **G**5 and **K**5. If the amateur will fit his telescope with an eyepiece of high power which contains two parallel, slightly separated crosswires, and if this eyepiece be also equipped with an adjustable divided circle 3" to 5" in diameter carefully fitted so the center of the ocular field and the center of the circle coincide, then he can measure position angles easily and pretty accurately. His record book can then show this aspect of the binaries as he watches through the years. He will not need a clock drive or equatorial mounting, although these will help. All he needs do (but this must be done anew for each object examined) is to adjust his eyepiece until the stars trail across between the parallel wires. This gives the 270°-90° zero mark for his circle. He then proceeds to measure the position angle of the double.

On the orbit diagram, the observations from 1866 to 1877 were all made by Dembowski who, without clock or micrometer, managed to make amazingly exact measurements which still are valuable today. So the amateur need not be dismayed by the elaborate equipment of the big observatories. In fact, the double-image micrometer described in **Amateur Telescope Making Advanced** can be constructed by anyone who has made a telescope, and it will give accurate results.

WALTER SCOTT HOUSTON

HINTS ON CHART CARE

The care of large sheets of paper, such as the Moon Sets, Skalnate Pleso **Atlas of the Heavens,** AAVSO charts, and the like, presents some difficulties that I have solved by binding the sheets between covers of tempered masonite.

This material is ⅛-inch thick, one side is smooth; it is strong and not too heavy, and sells for about 10 cents a square foot at lumber dealers. It is easy to saw with a fine-tooth handsaw or circular saw. For appearance, I have covered the boards with canvas, such as is used for folding chairs (obtainable in department stores), glued on. The bottom (back) cover is one piece, but the top (front) is cut lengthwise about two inches from its left edge. These two pieces are held together by a flexible hinge of Mystic tape (office-supply dealers) or glued linen. The covers and sheets are held together with aluminum ledger binding posts.

The Moon Sets were interleaved with tracing paper so that the formations could

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be traced as observed and the name shown. An index was also made and bound in the front. The Skalnate Pleso plates are easier to handle if they are hinged with white Mystic tape; an extra strip of paper held in the binding allows the full plate to open easily and lie flat. Spring clips (such as Bulldog No. 2) will hold the sheets open against the front cover.

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ROBERT J. BARR
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PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Melete, 56, 9.7. June 12, 18:57.6 −7-35; 22, 18:51.6 −7-00. July 2, 18:44.2 −6-48; 12, 18:36.5 −6-59; 22, 18:29.9 −7-30. Aug. 1, 18:25.6 −8-19.

Hebe, 6, 8.2. June 22, 19:50.0 −7-19. July 2, 19:42.9 −8-09; 12, 19:34.1 −9-20; 22, 19:24.5 −10-50. Aug. 1, 19:15.4 −12-33; 11, 19:08.1 −14-19.

Melpomene, 18, 8.8. June 22, 19:58.4 −8-07. July 2, 19:51.9 −8-35; 12, 19:43.1 −9-25; 22, 19:33.3 −10-34. Aug. 1, 19:23.8 −11-58; 11, 19:16.0 −13-28.

Amphitrite, 29, 9.3. June 22, 20:29.7 −27-40. July 2, 20:22.9 −28-12; 12, 20:13.9 −28-41; 22, 20:03.7 −29-02. Aug. 1, 19:53.3 −29-12; 11, 19:44.1 −29-09.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1953.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

SUNSPOT NUMBERS

March 1-2, 0, 0; **3,** 1, 0; **4,** 4, 0; **5,** 0, 14; **6,** 0, 0; **7,** 0, 6; **8,** 2, 0; **9-12,** 0, 0; **13,** 2, 7; **14,** 7, 15; **15,** 3, 8; **16,** 0, 7; **17,** 0, 0; **18,** 3, 8; **19,** 11, 10; **20,** 11, 8; **21,** 12, 10; **22,** 11, 10; **23,** 12, 10; **24,** 12, 9; **25,** 3, 9; **26,** 0, 7; **27,** 18, 17; **28,** 21, 25; **29,** 20, 32; **30,** 48, 47; **31,** 44, 48. Means for March: 7.9 American; 9.9 Zurich.

Daily values of the observed mean relative sunspot numbers are given above. The first are the American numbers computed by Neal J. Heines from Solar Division observations; the second are the Zurich Observatory numbers.

THE SUNSPOT MINIMUM

Minimum sunspot activity began late in 1952 when occasional zero values were in evidence. In 1953 January has yielded seven spotless days; February, 18 spotless days; and March, 11.

Prof. W. Gleissberg, director of the University Observatory, Bayazyt, Istanbul, Turkey, an authority on sunspot epochs, now predicts that minimum will occur during 1953, will be of short duration, and will be followed by a cycle slightly lower than the previous sunspot maximum of 1947, which was the second highest of all known sunspot cycles.

Up until November, 1950, although solar activity was declining, there had been no spotless days. At that time most minimum predictions were for late 1954 or 1955. The first spotless day of the current minimum occurred on December 19, 1950.

For comparison with this year's predicted minimum, the pattern of sunspot activity month by month during the previous minimum in 1944 is given here. The numbers of days with sunspots, month by month from January through December during 1944, were 10, 1, 13, 2, 4, 14, 11, 25, 24, 29, 22, 25. The numbers of days without spots for the same months were 21, 28, 18, 28, 27, 16, 20, 6, 6, 2, 8, 6.

NEAL J. HEINES
AAVSO Solar Division

MOON PHASES AND DISTANCE

Last quarter	June	4, 17:35
New moon	June	11, 14:55
First quarter	June	19, 12:01
Full moon	June	27, 3:29
Last quarter	July	3, 22:03

	June	Distance	Diameter
Perigee	5, 14h	229,700 mi.	32′ 20″
Apogee	18, 21h	251,100 mi.	29′ 34″
	July		
Perigee	1, 0h	228,300 mi.	32′ 32″

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

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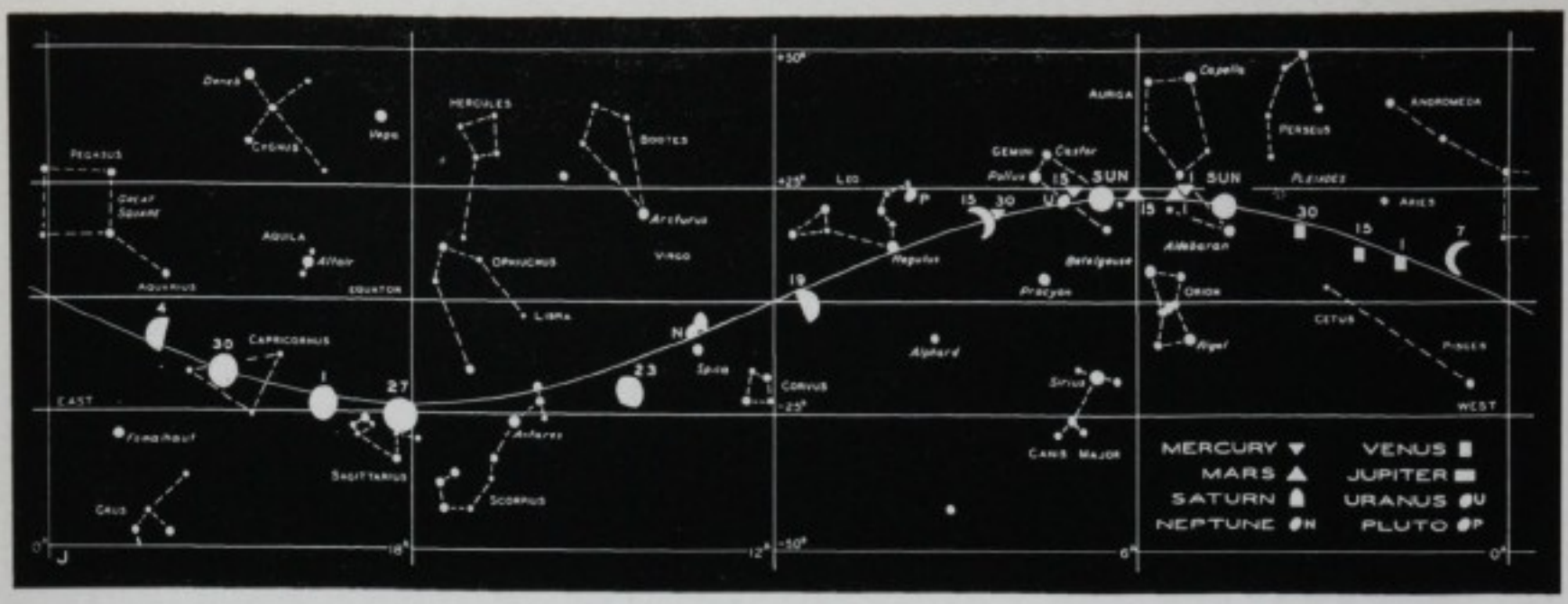

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury, an evening object all month, attains greatest elongation on June 27th, 25° 31′ east of the sun. The elusive planet becomes visible to the unaided eye the first few days of June, setting an hour after the sun, at magnitude −1.0. The best time to view Mercury will be in mid-June, when it will set over 1½ hours after the sun, appearing at magnitude 0.

Venus attains greatest elongation in the morning sky on June 22nd, 45° 46′ west of the sun. At this time, the planet rises 2½ hours before the sun, shining at magnitude −4.0. Telescopically, Venus appears 50% illuminated, the disk 24″ in diameter. The size of the disk is rapidly decreasing.

Earth arrives at heliocentric longitude 270° on June 21st at 17:00 UT. Summer commences in the Northern Hemisphere and winter in the Southern.

Mars will not be observable due to its proximity to the sun in the evening sky.

Jupiter reappears in the morning sky in the latter part of June, rising during the dawn.

Saturn, a fine evening object, will be on the meridian at 8 p.m. local time on June 11th. The planet will be located about 5½° north of Spica in Virgo. Eastward motion will resume on June 24th, at which time Saturn will be at magnitude +0.9. The ring and satellite systems are always interesting telescopic objects. Minimum inclination of the rings occurs about June 18th, 11°.9 to our line of sight.

Uranus will become invisible in the sun's glare as June progresses. On the 16th, Mercury will be in conjunction with Uranus, the latter 1° 27′ south.

Neptune may be observed until midnight, as an 8th-magnitude object approximately 1° south of Saturn in Virgo. The planet continues in retrograde motion and is at 13ʰ 20ᵐ.9, −6° 41′ (1953) on the 15th.

E. O.

A January Configuration of Planets and the Moon

The crescent moon, with earthshine on its darker side, Venus, and Mars are all in this photograph taken at the Forest Hall Observatory, Northumberland, England, on January 18th. The picture was transmitted by Frank J. Acfield. The camera, on loan from the British Astronomical Association, works at f/5.8, 19½-inch focal length, and was mounted on a 10-inch reflector. The exposure was 15 seconds on Ilford H.P.S. emulsion.

VARIABLE STAR MAXIMA

June 5, Z Ursae Majoris, 115158, 6.6; 9, S Hydrae, 084803, 7.9; 15, R Horologii, 025050, 6.0; 19, R Trianguli, 023133, 6.3; 23, S Coronae Borealis, 151731, 7.5; 25, T Centauri, 133633, 6.1; 29, R Andromedae, 001838, 7.0. July 2, R Lyncis, 065355, 7.9; 4, S Gruis, 221948, 7.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

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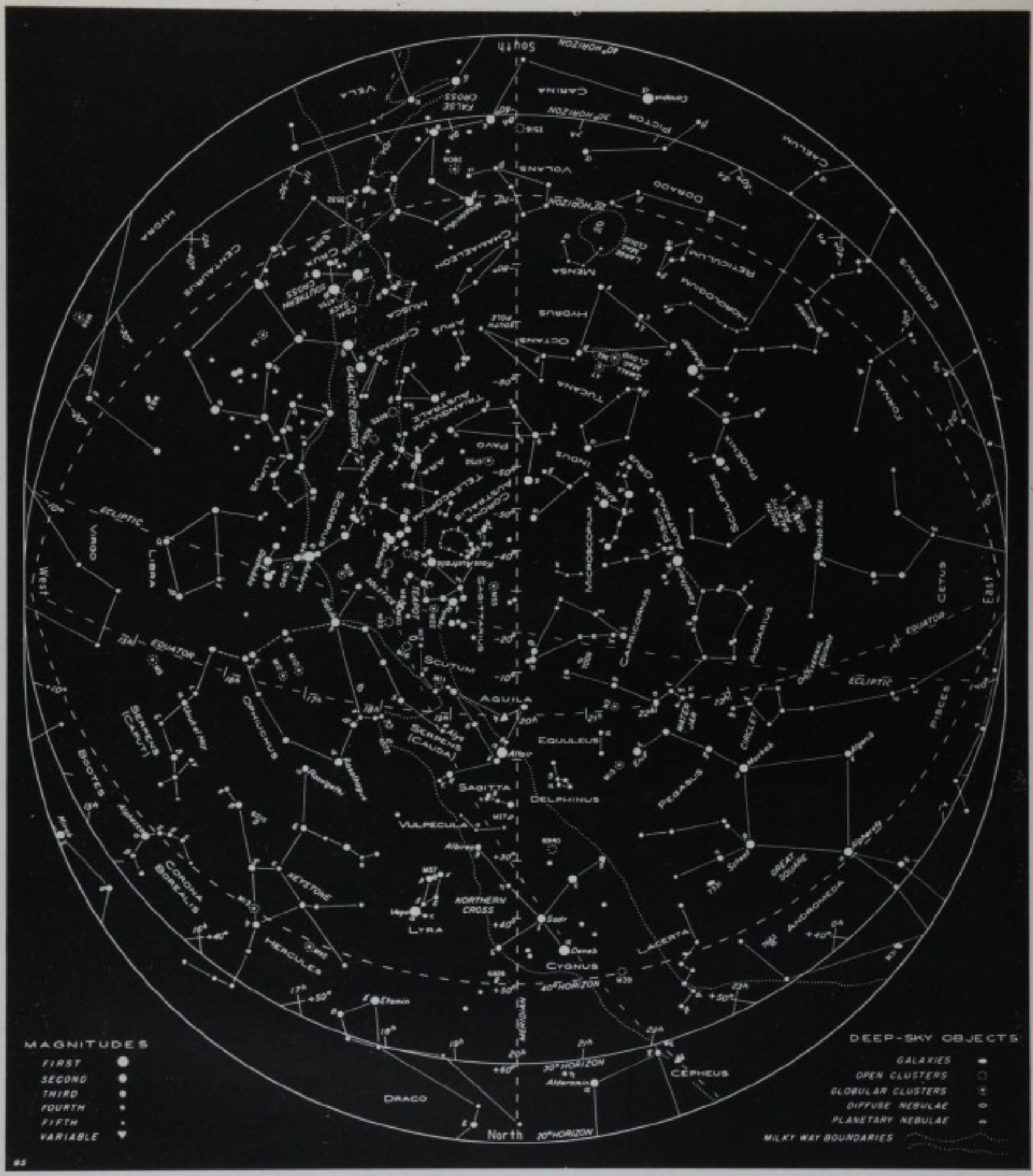


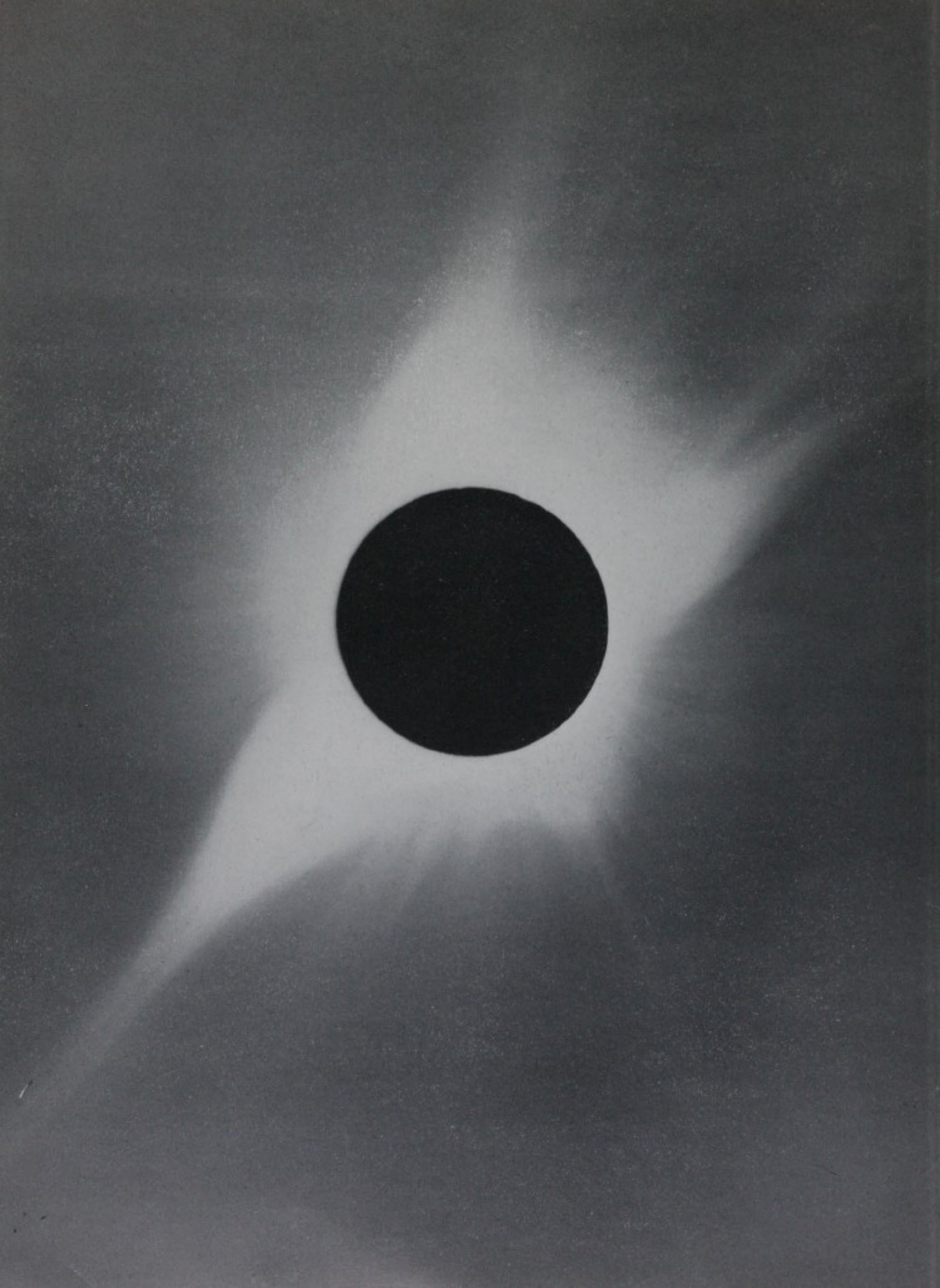
The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of September, respectively.

SOUTHERN STARS

FOR AN OBSERVER at 30° south latitude, at the times for which this chart is drawn, the brilliant portions of the southern Milky Way lie west of the meridian; the galactic center passed the zenith some 2½ hours earlier. Thus, a location in this latitude permits observation of the center of the Milky Way system under the best possible conditions, and allows equally good conditions for study in all directions from the center.

As described by Jean Dufay in **Sky and Telescope,** December, 1952, page 41, the galactic center is located at about R.A. 17ʰ 30ᵐ, Dec. −30°. For an observer at Philadelphia, this point cannot rise more than about 20 degrees above the southern horizon, and even for the 200-inch telescope this maximum distance is about 27 degrees.

In Arequipa, Peru, on the other hand, where Harvard's Boyden station was first established in 1890, the galactic center passes only 14 degrees south of the zenith. At Bloemfontein, South Africa, where the Boyden station has been located since 1927, this distance is reduced to only one degree, probably less than the accuracy with which the direction to the center of the galaxy has been established. The Cordoba Observatory in Argentina is equally well situated, at latitude 31½° south.

STARS FOR JUNE

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of June, respectively; also, at 7 p.m. and 6 p.m. on July 7th and 23rd. For other times, add or subtract ½ hour per week. When facing north, hold "North" at the bottom; turn the chart correspondingly for other directions. The projection (stereographic) shows celestial co-ordinates as circles.